Electronics World

MAY, 1969
60 CENTS

DESIGN DETAILS ON A DIGITAL IC TIMER

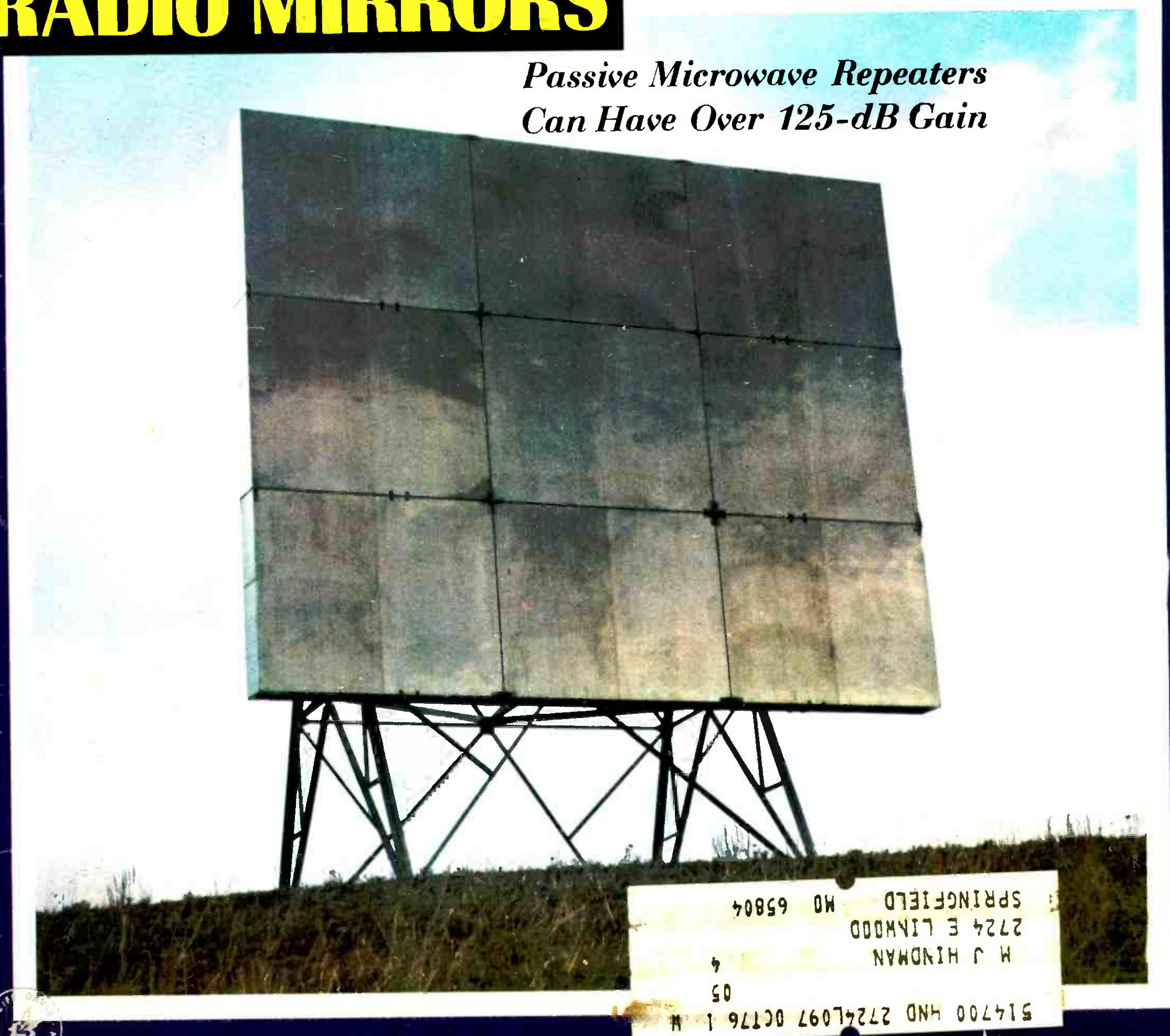
BUILD YOUR OWN LIGHT METER & EXPOSURE CALCULATOR

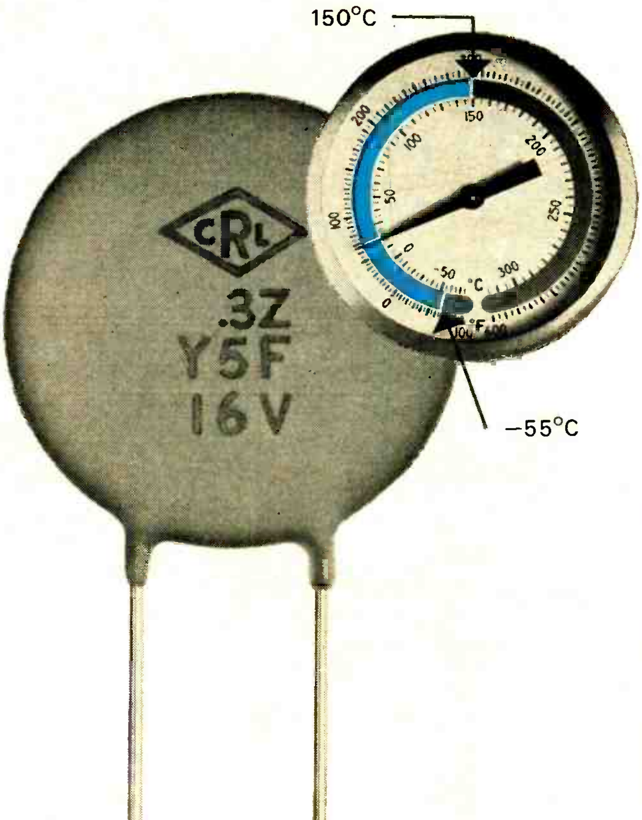
FORD'S NEW ELECTRONIC SPEED CONTROL

THE DOLBY SYSTEM—How it reduces noise and increases dynamic range of both master and home tapes.

RADIO MIRRORS

Passive Microwave Repeaters Can Have Over 125-dB Gain





Centralab gives transistor circuits longer, more reliable performance with NEW 16, 25 & 50 volt Ultra-Kaps®

Centralab engineers have achieved a new degree of temperature stability in semiconductor type, low voltage ceramic disc capacitors with their development of temperature-stable Ultra-Kaps. The 16 and 25 volt units can hold a maximum capacitance change of ±4.7%; 50 volt units as little as ±7.5%.

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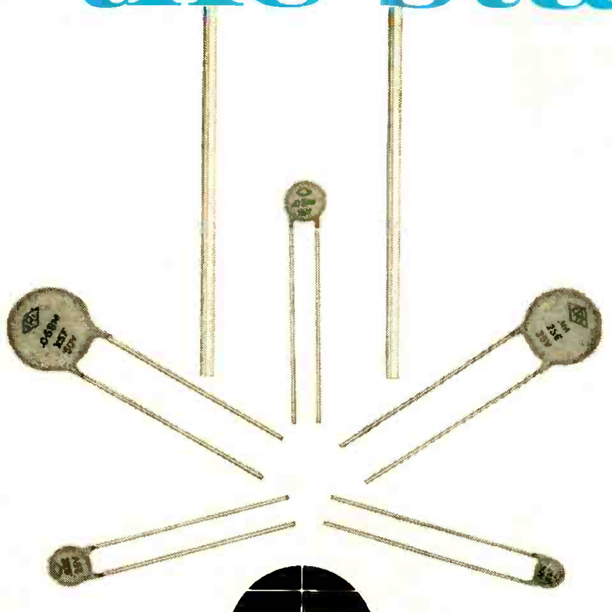
the stable ones



Ultra-Kaps are ideal for use in transistor circuits because they are operable to a frequency of 1 MHz. And they're still low cost units that replace more expensive mylar and "Hi-K" ceramic capacitors. On quantity orders, they're priced as low as 2½ cents each with delivery as short as 4 to 5 weeks. We can send you samples immediately for your evaluation.

Don't let your design plans melt away because of inferior capacitor performance. Get the ultimate, Centralab's stable Ultra-Kaps.

	16 volt		25 volt		50 volt	
Max. Diameter	Max. Cap. MFD	Min. I.R. Megohms	Max. Cap. MFD	Min. I.R. Megohms	Max. Cap. MFD	Min. I.R. Megohms
.290	.02	5.0	.015	65.0	.01	1000
.390	.033	3.0	.022	45.0	.015	1000
.405	.05	2.0	.033	30.0	—	—
.485	—	—	.05	20.0	.022	1000
.515	.068	1.5	—	—	.033	1000
.590	0.1	1.0	.068	15.0	.047	1000
.690	0.15	0.65	0.1	10.0	.05	1000
.760	—	—	—	—	.068	1000
.820	0.2	0.5	0.15	6.5	—	—
.920	0.3	0.33	0.2	5.0	0.1	1000

*Thickness: .156 inches maximum
Lead spacing: Discs less than .500" diameter, nominal lead spacing is .250"
Discs .500" and larger, nominal lead spacing is .375"

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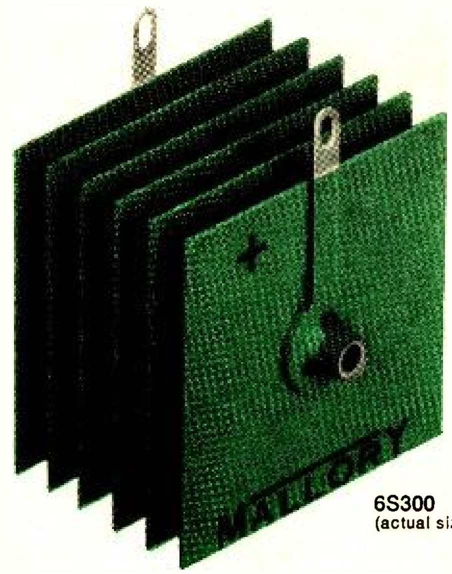
CIRCLE NO. 75 ON READER SERVICE CARD

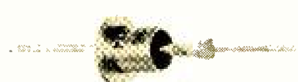
MALLORY Tips for Technicians

Look what's happened to the size of rectifiers.



6S300
(actual size)

Then the selenium rectifier was rediscovered. The 6S300 was cool and compact compared to the 5U4G. It could be tucked away underneath the chassis. And on occasion, these selenium rectifiers could be found wired up in a voltage doubler configuration without a power transformer. The 6S300 was rated for 117 VAC PRV at 300 ma. And was 1¾ inches square.

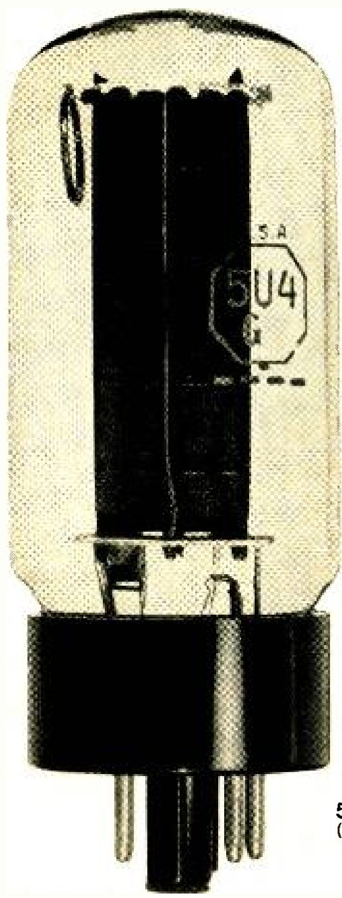


1N1096
(actual size)

A little later in the rectifier evolution was the highly efficient 1N1096 silicon rectifier. It ran cooler than all that came before it. It was rated for 600 VAC PRV at 750 ma. And it only measured .295 inches long by .380 inches wide.

1N4000
(actual size)

Finally, to bring us up to the present, we now have the 1N4000 silicon rectifier. A mere .225 inches long by .120 inches in diameter. This little giant is rated for 1000 VAC PRV at 2.5 amperes.



5U4G
(actual size)

Way back in the '50s nearly every TV set had a 5U4G rectifier tube in the power supply circuit. Large and cumbersome. Rated for 600 VAC PRV at 300 ma. It sometimes took two of them to keep a set running properly. The 5U4G gave off large amounts of filament heat causing many a burned finger. It was 4½ inches tall. And 1½ inches fat.

And in time, rectifiers will undoubtedly get even smaller. Over-all ratings will increase. And your nearby Mallory distributor will have them. See him now about his complete line of silicon rectifiers. Or write to Mallory Distributor Products Company, a division of P. R. Mallory & Co. Inc., Indianapolis, Indiana 46206.

DON'T FORGET TO ASK 'EM—*"What else needs fixing?"*

CIRCLE NO. 99 ON READER SERVICE CARD

THIS MONTH'S COVER shows a passive repeater of the type described in our lead story. Essentially a radio mirror, the reflector redirects microwave energy just as an ordinary mirror redirects light. This reflector measures 24 by 30 ft and is installed in a telephone company microwave system near Missoula, Mont. Designed for operation up to 13 GHz, this repeater provides about 110-dB gain in the 6-GHz band and about 120-dB gain in the 11-GHz band. Higher gains are also possible with larger reflectors or higher frequencies. Passive repeaters are used in hundreds of microwave systems around the world for transmitting voice, video, and data. Photograph by Ray D. Thrower.

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CONTENTS

MONTHLY FEATURES

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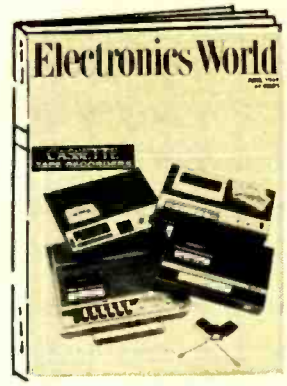
COMING NEXT MONTH



SPECIAL FEATURE ARTICLE:

CASSETTE TAPE RECORDERS

The hottest item in the consumer electronics market is probably the cassette tape recorder. Most major consumer electronics manufacturers are making them. Our lead article traces their development and cites differences and some problems. A Hirsch-Houck lab report commenting on the performance of a number of new cassette types is included for the technical man, as well as those interested in just good music.

EXPERIMENTAL LASER ENGINES
Lasers have been used for talking, for burning holes in metals, and for measuring distances. Now researchers are studying the use of lasers as thrustors which could send spacecraft hurtling toward the stars.

THE POWER FET
High-power field-effect transistors—capable of dissipating up to 8 watts—offer new design opportunities. Their characteristics and applications are discussed in this article.

ELECTRONIC LOADBANK
Like other electronic equipment, the quality of a power supply is only as good as its tests indicate. Here's a new concept in electronic testing which dynamically tests power supplies quickly and efficiently.

MULTIPLE-FUNCTION RELAY CIRCUITS
Take an unconventional circuit, trigger a conventional relay, and control the operation of almost any piece of remote equipment. Only two wires are needed—a hot lead and a ground.

TAPE RECORDER WOW & FLUTTER
Hi-fi buffs are always concerned about wow and flutter. Unfortunately, few know why the effects occur and how this distortion is measured.

All these and many more interesting and informative articles will be yours in the June issue of ELECTRONICS WORLD . . . on sale May 20th.

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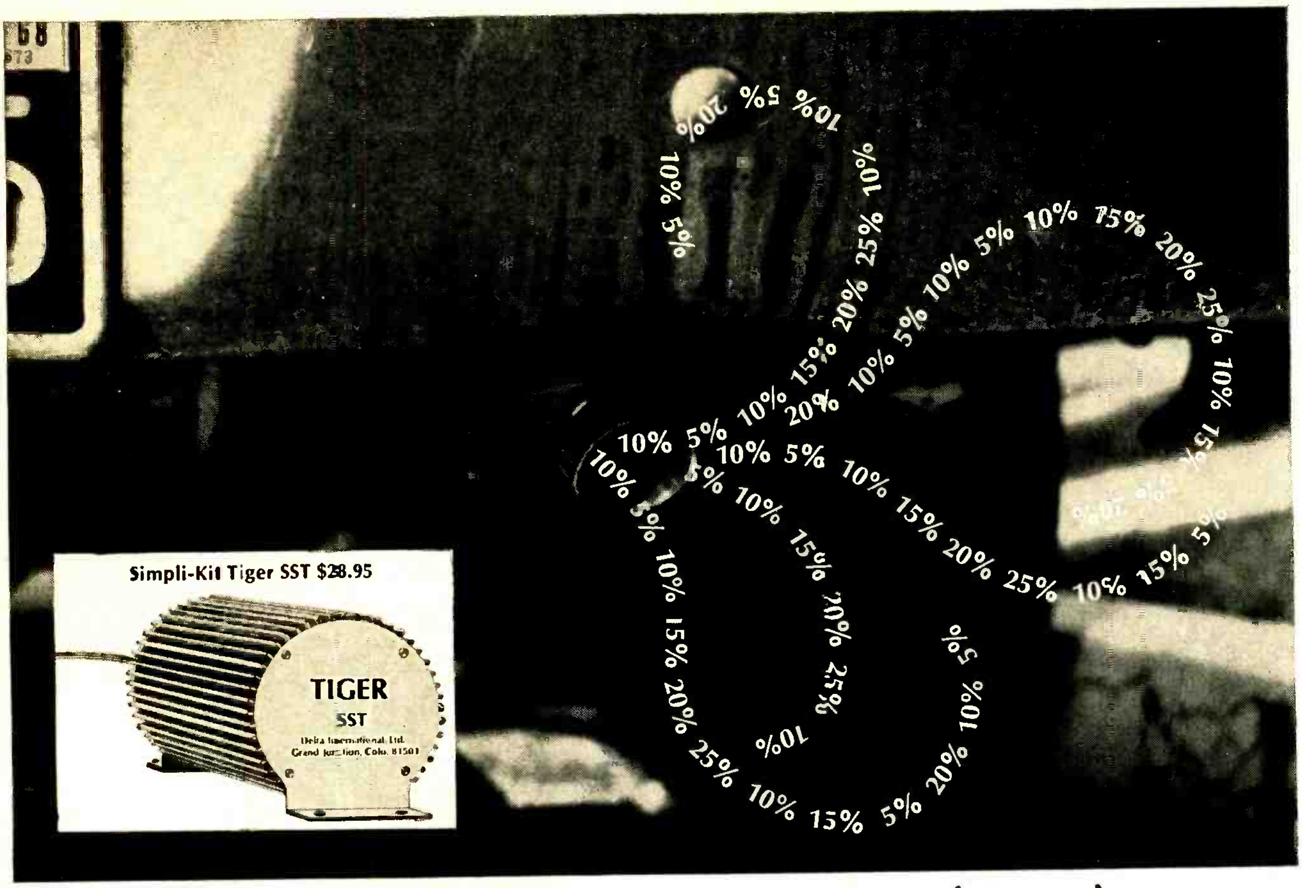

Capture that top 10% (at least) engine performance you're now blowing out the exhaust!

Announcing a new generation C. D. Ignition System—the Tiger SST.

Here, in a compact new unit, are all of the advantages of previous capacitive discharge systems that have been chalking up such impressive performance records the past several years—plus a good deal more. The dramatic results:

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Dealer/Distributor inquiries invited.

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CIRCLE NO. 110 ON READER SERVICE CARD

For the record

WM. A. STOCKLIN, EDITOR

HI-FI POWER-RATING PROBLEMS

ONCE again the Institute of High Fidelity (IHF) has been confronted with a potentially serious industry problem and has come out of it reasonably well. Not too long ago a rather prominent hi-fi manufacturer started to promote power-output figures of its hi-fi components with a ±1 dB tolerance. Quickly not to be outdone, others followed—and seemingly a new standard was introduced.

Situations of this kind are not new, particularly in an industry like ours where everyone is eager to develop some edge over his competition. We have gone through such standards measurements as continuous sine wave, music power, dynamic power, and peak variations of all three—not to mention EIA's present standard of music power at 5% distortion.

Assuming the ±1 dB measurement prevails, it means that an amplifier actually producing between 79 and 126 watts could be rated at 100 watts ±1 dB. It should be immediately obvious that no manufacturer would use this particular figure if his amplifier produced a power output anywhere above the minimum of 79 watts. Why the ±1 dB then? We are sure that an alert competitor would immediately decide to rate his amplifier with +0, −1 dB figure. This figure sounds much better. Or what's wrong with the idea of a manufacturer rating his amplifier at +0, −2 dB? To the non-technical person it sounds the same—yet in this case a manufacturer with an amplifier producing 63 watts would rate it at 100 watts +0, −2 dB. The entire intent is not necessarily to confuse the consumer, but regrettably that is the end result. Psychologically, higher power figures are most desirable. Unfortunately, most consumers do not realize that even if the power output of an amplifier is doubled the actual audible response is barely noticeable.

The IHF board of directors, at a recent meeting in Washington, decided that if any reference is made to IHF standards of measurements, power-output figures must be the actual values, *i.e.*, without any tolerances whatsoever. They are requesting that all member and even non-member manufacturers—including importers—conform to this request by September 1st. They are emphatic that no one can refer to the identifying initials IHF unless measurements are made and results reported in accordance with the Institute's Standard Methods of Measuring for Audio Amplifiers, IHF-A-201. There are no serious objections, though, to using any other methods of rating in addition.

Unfortunately, the IHF is not a regulatory agency and cannot legally enforce methods of measurements and ratings unless they refer directly to the IHF Standard.

Like any other industry, there are bound to be some mavericks, though. If nothing else, the present EIA standard still confuses most consumers. According to their rating, it is conceivable for an amplifier rated at 250 watts (peak EIA) to actually put out only 25 watts per channel. The 250-watt peak rating amounts to 125 watts peak power per channel, or 62½ watts music-power per channel. Remember that this power is quoted at 5% harmonic distortion. In the components industry, power figures are never given at distortion values over 2%, and invariably they are in the neighborhood of ½ to 1%. It is conceivable that this same amplifier would put out only about 40 watts per channel, music or dynamic power, under these reduced distortion figures. If steady-state power output measurements are made, this figure could drop to 30 watts per channel continuous (average) power. Also, it is quite likely that the original power rating was taken with only one channel operating at a time. In most cases, the power figure would drop from 10 to 20% where measurements are made with both channels operating simultaneously. This brings our final power figure down to about 25 watts per channel continuous sine-wave power.

It is unfortunate that this situation exists, but as long as the two segments of the industry continue to work independently there is no solution possible. We do feel, however, that government pressure will, in time, force some industry-wide standardization—not only in standards of measurement but, what is more important, in standards of rating the performance characteristics of all forms of hi-fi equipment. ▲

If the sound is good enough for him

The man at the console is an audio engineer at Bell Sound Studio in Hollywood. Here they record commercials: the full range. You've heard a lot of them. It's an exciting business and a competitive one. So they've got to be right.

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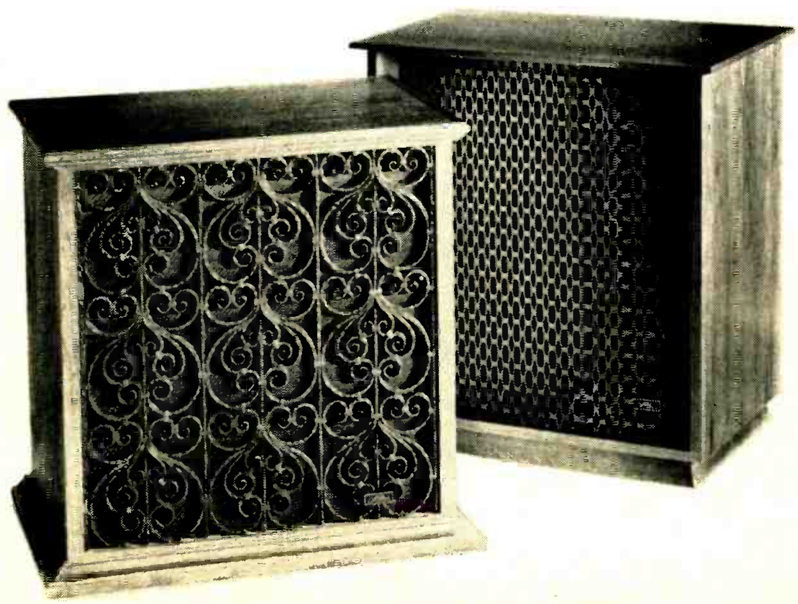

CIRCLE NO. 123 ON READER SERVICE CARD

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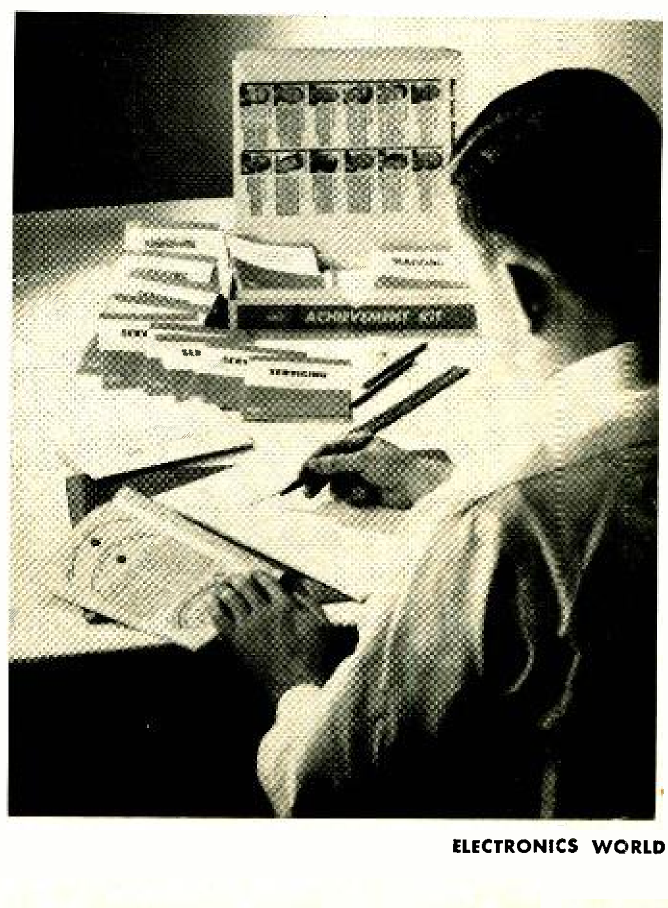

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By FOREST H. BELT /Contributing Editor

The Economy and Consumer Electronics

The new Administration is trying to cool the inflationary boom without slowing growth too much, the way we predicted (January column). President Nixon's economic advisers expect you'll notice a slowdown in the next month or so. One brake is also a drag on consumer electronics. That's the tight money market; there's no hint of relief before fall. Installment buying is slower than it might be otherwise. Higher wages might help, but the 10% tax surcharge is likely to keep cutting into that.

One side of the see-saw bodes well for servicers. When buying is inhibited awhile, owners apparently decide to fix up the old set. But, there's the same tight-money squeeze on repairs to be "charged"; strictly-cash service shops fare best.

Service technicians should not be fooled just because they take in more dollars. Inflation has boosted prices so much, a mere 4% increase in sales is like no increase at all. In fact, it could even mean less profit, since the same 4% applies to things they buy.

Direct Satellite TV

It may come sooner than anyone expected. The National Aeronautics and Space Administration (NASA) is financing a new study. One thing that has speeded progress is the success of the Apollo program; the satellite-to-home broadcast system NASA envisions will use equipment that is part of the Apollo Applications program.

An 8-GHz link will be used to send television signals up to the satellite. A frequency converter will shift the signals to about 650 MHz. Then a 25-kW u.h.f. transmitter, feeding a 30- or 40-foot parabolic antenna, will rebroadcast signals back to earth. For home TV sets, says NASA, all that's needed is a 14-dB yagi antenna. That's a far cry from the cryogenic receivers and 85-foot dishes anticipated not long ago.

There's also a new space antenna that might be applicable. *TRW Systems Group* has an antenna that is a phased array of helices. Special construction lets the array "pop out" into position when the antenna reaches orbit. A large area of the earth is covered with a single antenna.

Spotlighting TV Tuners

Sarkes Tarzian caused a slight stir by announcing a detented u.h.f. tuner. The new tuner is one answer to the FCC's demand that u.h.f. tuning be as simple as v.h.f. The tuner has six u.h.f. positions, any of which can be preset anywhere in the u.h.f. band. The user merely sets the detented dial to a u.h.f. position and dials the desired station with the fine-tuning knob. Thereafter, that station appears at the position on the dial.

RCA already has a detented u.h.f. tuner in top-of-the-line models. Its dial is separate from the v.h.f. dial. In the *Sarkes* tuner, both bands are tuned with the same pair of knobs. Both detented u.h.f. tuners can be motorized for remote control.

We expect variable-capacitance-diode tuners to appear this year, probably in June. *RCA* is working on one, but can't say if it'll be ready that soon. *Standard Kollsman* has one, but doesn't say who will use it, or when.

Who's Tops in Color-TV?

In another year, says the Japanese Ministry of International Trade and Industry, Japan could build more color sets than the U.S. does. Last year, Japan produced more than 2.5 million color sets; an estimate for this year says 4 million. By 1970, the Japanese expect to produce more than 6.5 million sets—or at least be able to.

We can't help wondering where they'll sell them. Our own manufacturers couldn't reach the 6-million mark in 1968, although they expect to surpass it in 1969. If Japanese companies produce even 6 million color sets in 1970, they'll have to export an awful lot of them. Their color-set sales at home in 1968 were about 1.8 million, and exports to the U.S. were 600,000; almost 100,000 more went to other countries. Even if sales double in Japan (they did from 1967 to 1968), that will leave about 1.5 million to sell abroad.

Can they more than double their share of the American color-set market? If not, and there's no tight control of production, there could be a real glut of color sets that would drive profits down even more.

When Listening's a Crime

Here's a warning to those who buy multiband portables with police bands. Caught with the unit in an automobile, they could be hauled into court and have the radio confiscated. It's against the law in many states to have such a unit in the car, even though you're listening to other bands. At home, you can listen to whatever you please. Only then, the Federal Communications Act takes over, admonishing you not to divulge what you hear to a third party, even in idle discussion.

Hi-Fi Companies Get Together

Merger is the name of the game in all fields nowadays. It's changing the face of the hi-fi industry, and has been for several years. If you haven't kept up, you can't tell the players any more without a program.

Lately, *Astatic Corp.* has acquired the cartridges and microphone line of *Sonotone*, recently a subsidiary of *Clevite Corp.* This merger follows the line of a similar merger about this time last year, when *Astatic* bought *Euphonics Corp.'s* phono-cartridge operation. The inventory and other assets of *Sonotone* will be transferred to Conneaut, Ohio, home office of *Astatic.*

And *Fisher Radio* has agreed to be absorbed into *Emerson Electric. Fisher* is only one of many hi-fi equipment makers that have gone the merger route in the last few years. There's *Jensen (Muter Company), JBL (Jervis Corp.), Marantz (Sony/Superscope), Harman-Kardon* (also *Jervis*), *Benjamin (Instrument Systems Corp.), BASF (Computron), Bogen (Lear Siegler, Inc.), Magnecord (Telex Corp.), Viking (Telex), University (LTV), Altec Lansing (LTV),* and so on. If you wonder why, one answer may be tight money. Old-line companies get into the expand-or-die bind and it takes money to stay alive. The large conglomerates, publicly held, have better access to the money markets. There are still a few holdouts in the hi-fi field, but probably not for long.

Safety in Home Electronics

Early-spring hearings by the National Commission on Product Safety pinpointed trouble spots in home-entertainment electronics. The full report is due in the White House by June 1.

Safety standards earned more than average attention. There was a lot of talk about making standards easier for the public to understand. More to the point, it would seem, is the matter of how valid the standards are—and how well they're adhered to. Several witnesses insisted that manufacturers use "seals of approval" that mean absolutely nothing. Others say buyers need clearer operating instructions, and more noticeable and forcefully worded cautions against improper and dangerous use.

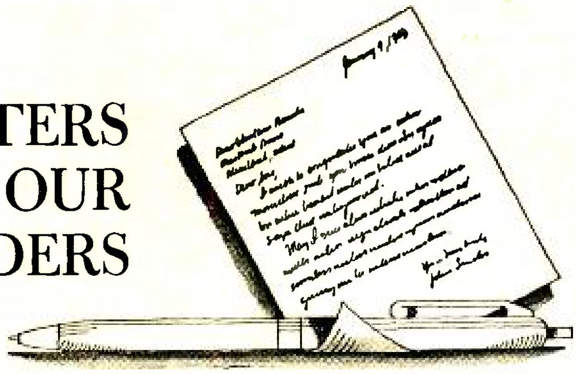
One group, the United States of America Standards Institute, has already started a program to simplify wording of instructions and to inform the public of minimum safety factors to watch for when buying. USASI is not a government agency, but a private association that brings together 160 technical-standards-writing groups and about 900 manufacturing companies. The group doesn't test products, but plans a system of certification for member-company products; they'll be tested by independent testing labs.

The National Commission wants to see home-electronics (and other) manufacturers set up their own voluntary safety specifications. Many manufacturers, particularly of imported items, have no standards anyone knows about. It's time for the industry to get on the ball, or there'll be laws like the automotive-safety law to contend with—causing endless paperwork and monitoring expense.

Flashes in the Big Picture

Westinghouse, already out of TV manufacturing, expects to quit making picture tubes too; may withdraw from consumer electronics altogether. . . . Another casualty of profit squeeze in consumer electronics is *National Video Corp.*, maker of TV picture tubes; suspended operations in early March, pending reorganization attempts. . . . *RCA*, long officially known as *Radio Corporation of America*, changes name to *RCA Corp.* . . . *Sony* expects to have color-TV ready for sale this summer; probably will use version of one-gun, three-beam Trinitron picture tube, if suit filed by *Gulf & Western* (owner of Chromatron rights) doesn't inhibit. . . . *Sylvania* is importing some black-and-white sets from Hong Kong. . . . *RCA* has been trying out new warranty plan for home instruments in Midwest; plan is to reimburse for in-warranty service at shop's regular rates; now being tried in five other areas, plan is expected to spread nationwide this year. . . . *Hitachi* hopes to have new all-transistor small-screen color set ready for U.S. in late fall. . . . *Setchell Carlson* has attaché-size service case for plug-in PC's of prototype color set; price about $200. ▲

LETTERS FROM OUR READERS



TRANSISTOR BETA VARIATION

To the Editors:

Maybe I can bail Rufus Turner out of his problems on those 2N2712's ("Transistor Beta vs Source Resistance," Nov. issue and Feb. "Letters" column).

The early ones were molded with a brown translucent epoxy, and would admit radiated light from overhead fluorescent lights. This, naturally, garbaged up apparent *beta* when a large base resistor was used. I had no end of trouble with this in a design several years ago until I found out what was causing it and used black paint on them.

The manufacturer was shocked when I complained, but their tests verified it. As a result, they sent me a new batch molded in black epoxy, and I finished the design job. Black epoxy has been standard in the industry since.

I hope this gets the monkey off Rufus' back. He's an old timer in this game—I've enjoyed his articles for years.

WALTER T. STEVENSON
Instructor, Technical Electronics
A.V.T.S.
Kansas City, Kansas

* * *

FERRITE CORES FOR C-D SYSTEM

To the Editors:

We refer to "Unique Capacitor-Discharge Ignition System" on page 45 of your January, 1969 issue. As an authorized distributor of *Ferroxcube* parts we are in a position to supply the cores for *T*1 and *T*2 transformers. Price for K3-005-01-3E and 266T125-4C4 cores is $3.50 for both. Please send check with the order.

HUGH A. MARTIN, Sales Mgr.
Elna Ferrite Labs, Inc.
Box 395
Woodstock, N. Y. 12498

Also, equivalent Indiana General *cores are listed in the* Newark Electronics *(500 N. Pulaski Rd., Chicago, Ill. 60624) catalogue. Incidentally, wire size for T2 should be #38 rather than #28. Although we did manage to wind a T2 with the heavier wire, there was no room for a mounting bolt.—Editors*

* * *

TRANSISTORS MADE OF GLASS

To the Editors:

Reference is made to the article "Transistors Made of Glass" by A. H. Seidman in your February, 1969 issue. In Fig. 1A on page 68 a glass device connected in parallel with a resistive load and a constant voltage source is shown, and it is claimed that the device controls the voltage appearing across the load resistor.

This diagram tends to be somewhat misleading since from basic electrical circuit considerations we know that the voltages appearing across elements in parallel are always the same and therefore e_o will always be equal to the e.m.f. of the voltage source. This apparent source of difficulty may be overcome simply by placing a resistor in series with the 60-Hz source.

ROBERT MAURO, Ph.D.
U. S. Army Electronics Command
Fort Monmouth, N. J.

Thanks to Dr. Mauro for pointing out our somewhat oversimplified simplified diagram.—Editors

* * *

SCA FM STATIONS

To the Editors:

Are there any FM stations currently operating in New York City using SCA (subcarrier authorization) and what subcarrier frequencies do they use?

MARTIN SANDERS
Brooklyn, N. Y.

According to a list we just received from Music Associated, 65 Glenwood *Road, Upper Montclair, N. J. 07043, there are five FM stations in New York City now using SCA transmissions for one purpose or another. These are WHOM (41 and 67 kHz subcarrier), WPIX (67 kHz), WNCN (32.5 kHz), WRFM (41 and 65 kHz), and WNYC (32.5 kHz). The list, which is available for $1 from the company, shows about 550 U.S. FM stations using SCA, mostly operating on a 67-kHz subcarrier frequency.—Editors.*

* * *

REFLECTIONS ON WORLD AIRLINES

To the Editors:

In the February issue of ELECTRONICS WORLD, the column "Reflections on the News" carried the following item under the Apollo Spacecraft heading:

"*World Airlines Inc.* was fined $5000 for not having a precise navigation system on board one of its planes which strayed over Soviet territory and was forced down with 214 soldiers aboard. Perhaps an inertial system could have helped."

The airline to which you refer was *Seaboard World Airlines,* not *World Airways.*

TOM WHEELER, Asst. to Pres.
World Airways, Inc.
Oakland, Cal.

We are sorry for any confusion that may have resulted from our not having given the complete name of the company that was involved.—Editors

* * *

BEING A GOOD SERVICE CUSTOMER

To the Editors:

I should like to add my words of approval for John Frye's "How to be a Good Service Customer" (January issue). Mr. Frye has written a good column for a long time but this one is a showpiece. He said what was necessary and said it well.

Mr. Frye has assessed the serviceman's thinking very well. We don't need work; we need money. We don't need more customers; we need better customers. The run-of-the-mill customer of today will no longer support an adequate service shop, let alone a good one.

Let us hope that Mr. Frye will follow this article with others equally incisive. It is high time to begin a weeding-out program in the service business but let it be applied equally on both sides of the counter.

FRANCIS C. WOLVEN
Saugerties, N. Y.

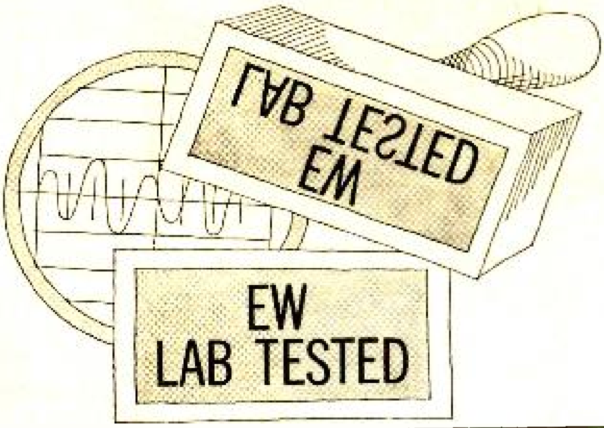
To the Editors:

I just finished reading John Frye's article on "How to be a Good Service Customer." All of his articles in the past have been humorous, enjoyable, and interspersed with helpful hints. This one hit the nail right smack on the head; I almost stood up and cheered. I know I am not alone now in saying that nothing bothers me more than having a customer watch my every move while I am servicing his set. It never seems to fail that when your train of thought is clicking right on down the line and you know you are close to the fault, the inevitable "What about?" and "How about?" or "Why don't you?" breaks it.

I ask for permission to have his "10 Commandments" printed on the back of my personal advertisement cards. His extra service charges for "watching," "giving advice," and "following that advice" would make a dandy sign to hang over the service bench.

I believe this article should be advertised and will deem it a pleasure if I am allowed to do my small share. Thank you sincerely for a long overdue aid to the serviceman.

GEORGE SCHUESLER
Jersey City, N. J. ▲



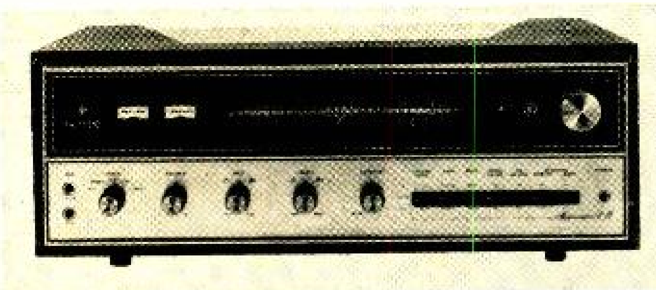
HI-FI PRODUCT REPORT

TESTED BY HIRSCH-HOUCK LABS

Scott LR-88 AM/FM-Stereo Receiver
Sony TA-2000 Stereo Preamplifier

Scott LR-88 AM/FM-Stereo Receiver

For copy of manufacturer's brochure, circle No. 23 on Reader Service Card.



THERE are several reasons, other than economy, why people build high-fidelity components from kits. True, one can save a substantial sum, especially on a rather complex instrument such as a stereo receiver, by assembling a kit. However, if the time expended is taken into consideration, one's hourly return may well fall below minimum wage standards.

Another, less tangible consideration is the pride and feeling of accomplishment in building a sophisticated electronic instrument which can bring pleasure to the builder for years to come. Even if one understands nothing of the theory of operation of the finished product, the mere act of assembly is rewarding.

Although most present-day kits assume no technical knowledge on the part of the builder, it is possible to learn a great deal from assembling a well-designed kit. The *Scott* LR-88 AM/FM-stereo receiver is an excellent example of a kit whose assembly is simplified to the utmost, yet remains a most educational process.

The parts for each section of the receiver are grouped under plastic windows in an expanded polystyrene tray. Even the wires are pre-cut, stripped, and tinned. The large, spiral-bound manual makes liberal use of detailed photographs, exploded views, and multi-color drawings, and leaves literally nothing to the imagination. The manufacturer states that no previous kit-building experience is required for successful construction of the LR-88, and this claim seems to be justified. In this respect the LR-88 is distinctly different from some other stereo-receiver kits which are suitable only for experienced kit-builders.

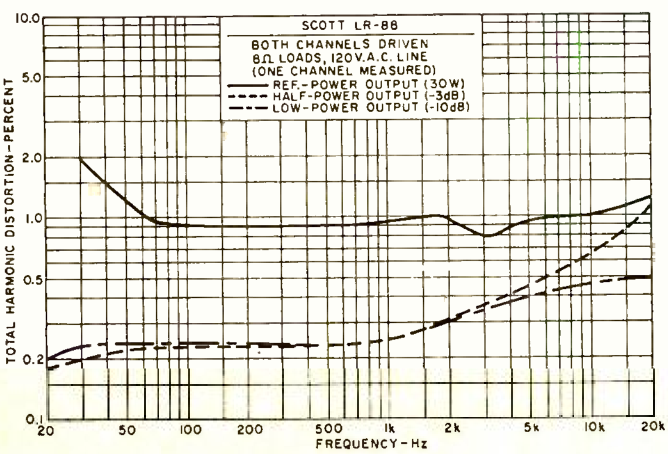
The LR-88 is essentially the same as *Scott's* Model 388-B but sells for substantially less. In appearance, it differs from the 388-B in having two tuning meters, one for zero-center FM tuning and the other as a relative signal-strength and AM-tuning indicator. The only difference in control functions is the replacement of the mode selector of the 388-B (which has the ability to play either channel through both outputs, to reverse channels, or to parallel them for mono) by a simple mono/stereo push-button on the LR-88 which physically replaces the rumble filter of the 388-B.

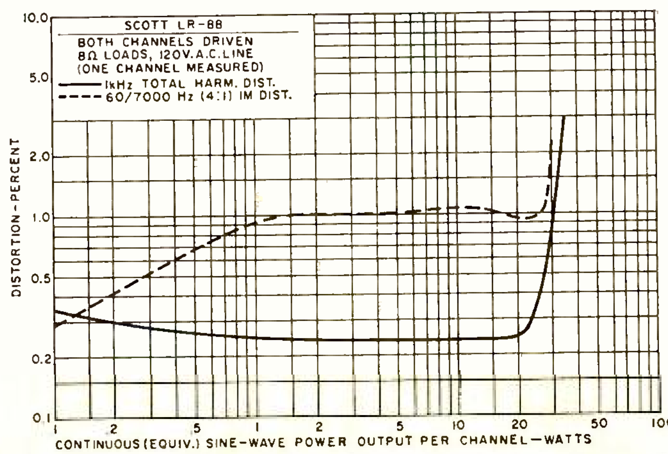
The LR-88 has an FET front-end, and an integrated circuit (IC) i.f. amplifier, followed by an IC limiter, ratio detector, and switching-type FM-stereo demodulator. It has an FM interstation muting circuit that senses output before the limiter stage, amplifies and rectifies it, and uses it to cut off the following limiter stage in the absence of a signal. The automatic stereo switching circuits operate in a similar manner in the multiplex demodulator, switching to mono if the signal is noisy or if a pilot carrier is not present.

The audio amplifier of the receiver is rated at 30 watts continuous power per channel into 8-ohm loads, with both channels driven. It has switchable loudness compensation, microphone and RIAA equalized phono inputs, tone controls, and a high-cut noise filter.

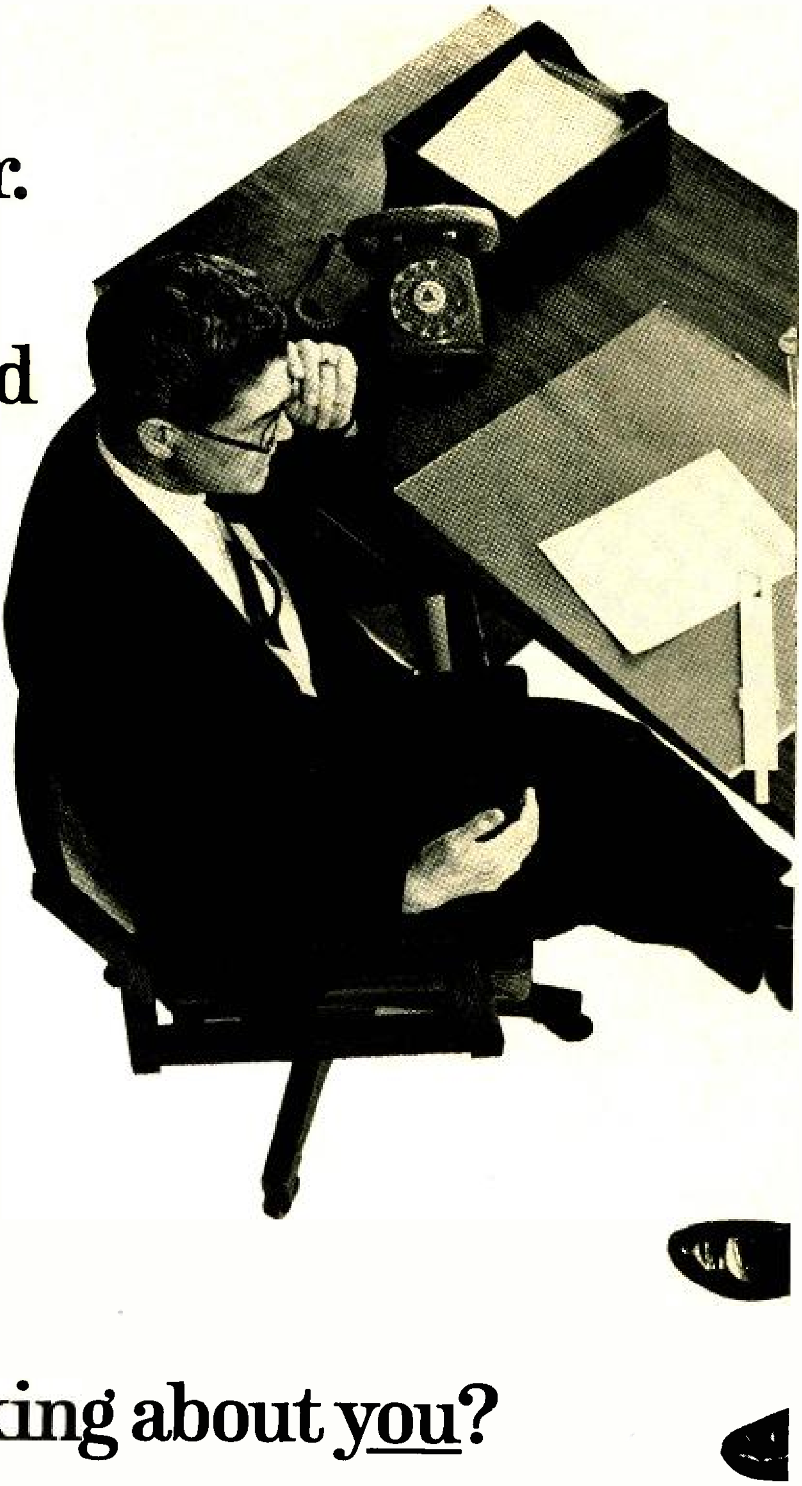
All major sub-assemblies, including the front-end, i.f. strip, multiplex, and audio control circuits are supplied fully wired and aligned. The kit assembly consists largely of mechanically mounting the parts, wiring the interconnec-

(*Continued on page 75*)





"He's a good worker. I'd promote him right now if he had more education in electronics."



Could they be talking about you?

You'll miss a lot of opportunities if you try to get along in the electronics industry without an advanced education. Many doors will be closed to you, and no amount of hard work will open them.

But you can build a rewarding career if you supplement your experience with specialized knowledge of one of the key areas of electronics. As a specialist, you will enjoy security, excellent pay, and the kind of future you want for yourself and your family.

Going back to school isn't easy for a man with a full-time job and family obligations. But CREI Home Study Programs make it possible for you to get the additional education you need without attending classes. You study at home, at your own pace, on your own schedule. You study with the assurance that what you learn can be applied to the job immediately.

CREI Programs cover all important areas of electronics including communications, radar and sonar, even missile and spacecraft guidance. You're sure to find a program that fits your career objectives.

Reflections on the news

Trade Secrets . . .

and the intentional (or unintentional) disclosure of proprietary company information have recently received a great deal of attention in the press. It's an old problem, but the rapid pace at which technology is developing is forcing a new, hard look at the problem.

In the June 1968 issue of ELECTRONICS WORLD, an article "Trade Secrets: The Courts and You" by Maurice J. Hindin of the Beverly Hills, California firm of *Hindin, McKittrick & Powsner*, was published. Hindin attempted to explain to employees and employers the limits of their responsibilities, and where technical competence ends and irresponsible disclosure (of trade secrets) begins.

Here's an example of the difficulty which indiscretion can cause. Recently, *Applied Materials Technology, Inc.* filed suit charging two former employees with disclosure and wrongful use of trade secrets. The suit also attempts to enjoin two other firms from using these secrets in competition. At the time this column was written, it appeared that the parties concerned would settle out of court. However, the whole problem could probably have been avoided if the employees were more aware of their rights and their obligations.

Wiretapping . . .

or electronic eavesdropping is again fashionable. Bugging, except in national security cases was forbidden by an executive order signed by President Johnson in June, 1965. But, President Nixon's appointee U.S. Attorney General John N. Mitchell successfully countermanded the order when he confirmed that he had authorized the use of a number of wiretaps since he took office on January 20th. Presumably, these taps were not entirely concerned with national security problems.

However, many of the big manufacturers of electronic snooping equipment have quit the game. *Continental Telephone Supply Co.*, which was once one of the largest producers, says they now specialize in telephone scrambling devices and industrial security radar systems. *Security Electronics Inc*, another big producer, has taken the attitude that there never was a really big market for such devices and have gotten out of the business to a large degree.

But, if you think that bugging, anti-bugging, or other electronics surveillance equipment is hard to obtain, take a look at the ads in the back of some of the popular electronics magazines.

Anti-Pollution Devices . . .

have so far been the weakest link in the pollution monitoring and control chain. Instruments used for pollution monitoring are not sensitive enough to environmental changes; consequently dangerous conditions, such as heavy smog, arise before warning is given. Even more important, and hard to understand, is the lip service which city fathers in many large industrial cities have given to pollution control. Many recognize the need, but few—including those in government and industry—have done anything about it.

True, some companies are working on new detection equipment; and other organizations are developing means of determining when pollution tops the danger level. Unfortunately, this effort isn't great enough. What is needed are instruments which can reliably "predict" conditions as well as display present situations. And perhaps, more important, much closer cooperation among the Federal government, state, and city agencies is needed.

Here are a few of the new instruments now in the works: a laser monitor for carbon dioxide; filter photometers to measure ozone; ion electrodes to measure fluorides; gas chronographs, portable automatic weather stations; new weather radar; and satellite systems which will be able to detect pollution moving from one large city in the direction of another.

Hijackings . . .

continue to plague the airlines, and it seems there's little that can be done about it. So far, hijackers have had the upper hand, mostly due to the reluctance of flight crews to jeopardize passengers' safety. Loud cries for help have been emanating from the Federal Aviation Administration. The electronics industry is listening, if somewhat guardedly.

The problem is a two-sided one. What the FAA needs is a reliable system for detecting guns, bombs, and other dangerous weapons. It needs this system now but there are no off-the-shelf devices which can fill the bill. A long development time is required for new devices and the FAA is reluctant to pay development costs. (The development costs for systems of this nature would be extremely high because of the very small market potential.) Thus the situation becomes almost impossible.

It has been reported that the FAA is looking at fluoroscopes and other devices which could sound an alarm when the presence of metal is detected. Such systems are in use in a number of prisons around the country. It's unlikely, however, that airline passengers will stand still for such shenanigans even if it is for their own good.

While no one can blame the FAA for the popularity hijacking is enjoying, it is also obvious that little has been done to make flying to Miami, from anywhere, safer.

Cut the Cost . . .

of IC's and maybe twice as many of these components will be used next year. Many manufacturers, particularly those in the consumer electronics field, would like to use them; but the price has been prohibitive. Scientists at *Bell Telephone Laboratories* may have come to the rescue. They have developed several new fabrication techniques which could reduce the cost of bipolar integrated circuits substantially. Until now, volume production has been the main reason for price drops.

One technique, called "collector-diffusion isolation," is proposed for circuits having moderate switching times and moderate power dissipation. It uses a *p*-type substrate and a *p*-type epitaxially grown upper layer. An *n*-type diffusion is used to set up the collector-contact areas, define the base of the transistor, and form resistances on the substrate. *Bell* says that collector-diffusion isolation eliminates one or two masking operations, and a transistor needs only about a fourth the area of standard buried collector types.

Another technique, "base-diffusion isolation," can be used for transistors with or without buried collectors. Base-diffusion isolation uses a shallow and narrow isolating ring around the transistor. It is created simultaneously with the base of the transistor (eliminating a diffusion step). A conventional *p*-type substrate is used with an *n*-type epitaxial layer. By applying a negative bias voltage to the *p*-type ring, an electric field is created which sweeps the area below the ring clear of *n*-type carriers.

According to *Bell Labs*, low-power IC memories and shift registers are being studied as possible applications for these new components.

Some Thoughts . . .

about things going on. Photographs taken by Astronauts during Apollo 9's earth orbits may lead to a better understanding and management of the Earth's water, mineral, agricultural, and other resources. The high-flying spacemen conducted a multi-spectral photography experiment to obtain the photographs. This was another first. . . . Medical men concerned that "rock" musicians are losing their hearing from exposure to heavily amplified electronic music. Sound levels near bandstands average 100 dB, often peaking at 120 dB. The maximum safe level is said to be 85 dB. *Sigma Engineering Co.* has developed a device called the "Lee Sonic Ear Valve," which they claim protects against harmful noise without plugging the ears—much the same way that sun glasses protect the eyes against glare. . . . Federal Aviation Administration to survey more than 2300 general aviation airports. It is to determine their financial status, so the FAA says. . . . Electronic Industries Association claims 1968 a "very good year" for consumer electronics. Sales of just about everything are up. . . . FM broadcasters lobbying in Washington for a bill which would require all automobile receivers to be able to pick up both AM and FM broadcasts. . . . Electronic Industries Association of Japan says that Japanese electronics, one of the country's fastest growing industries, is expected to continue its upward trend at a rate twice that of Japan's Gross National Product. Sales overseas, particularly in the U.S., account for a large percentage of the sales volume. . . . Reserve a table at the Waldorf before you leave home? Can do, if you ask the computer. Central computers in New York and Los Angeles (another is being set up in Chicago) have their memories crammed full of information about seats available, what stars are performing, etc. Over 1200 electronic ticket offices around the country are able to interrogate the computers and then make confirmed reservations. . . . According to the Engineers Joint Council, there has been a 16% decline in the number of graduate students enrolled in engineering schools. Master's degree candidates in their second or later year of study have dropped by 56%. Apparently, the elimination of graduate student deferments is the cause. . . . Bill Lear, the electronics expert and producer of the now famous "*Lear* Jet," is researching steam cars and buses and plans to build 25 prototype steam cars this year. Electronics, automatic fuel control, TV, etc. will play a heavy role in the *Lear* steamer. . . . *Owens-Illinois* claims to have developed a new material for medium- and large-scale production of IC's. It's called RZ glass. ▲

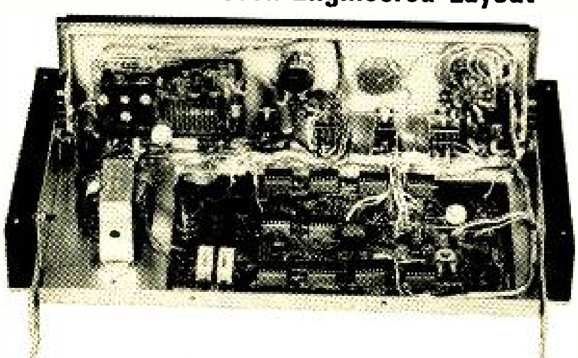
For Top Performance And Value In Electronics —

Introducing The NEW Heathkit® IG-28

Color Bar — Dot Generator...

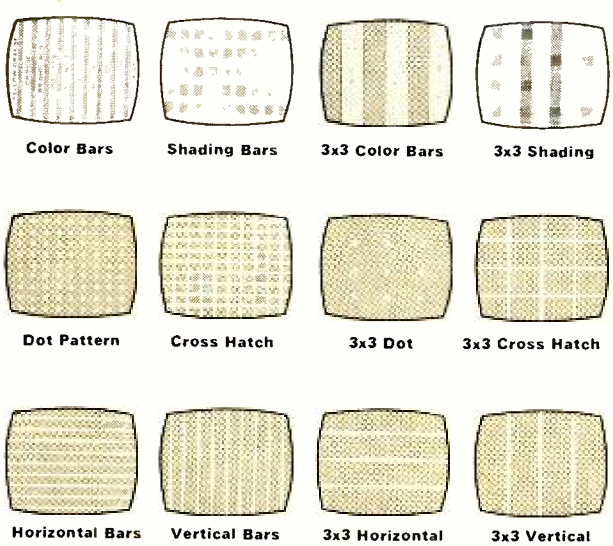
Advanced IC Design Gives 12 Patterns Plus Clear Raster Display & Eliminates Divider Chain Instability Forever!

Stable Integrated Circuitry And Well-Engineered Layout



Circuit Board-Wiring Harness Construction. Note the extremely clean, open layout — another advantage of integrated circuitry. The Video board is upper left, the Divider board mounts on the chassis.

Fast Switch Selection Of Either Standard 9 x 9 Display OR Exclusive Heath "3 x 3" Display



The Most Advanced Instrument In Color TV Service

• All solid-state construction using Integrated Circuitry • No divider chain adjustments • Stable pattern display — no flicker, bounce or jitter • Produces 12 patterns plus clear raster • Instant switch selection of all functions • Exclusive 3x3 display plus standard 9x9 display of all patterns • Horizontal lines only one raster thick for added accuracy • Variable front panel tuning for channels 2 through 6 • Variable front panel positive and negative video output • Front panel negative going sync output • Two handy AC outlets on front panel • Built-in gun shorting circuit with lead piercing connectors • Front panel switchable crystal controlled sound carrier • Copper-banded transformer to reduce stray fields • Safe three-wire line cord • Fast, easy construction with two circuit boards and two wiring harnesses

The new Heathkit IG-28 is the ultimate signal source for all Color and B&W TV servicing. No other instrument at any price will give you as much stable, versatile TV servicing capability. Here are the details:

All Solid-State Circuitry produces dots, cross-hatch, vertical and horizontal lines, color bars and shading bars in the familiar 9x9 display . . . plus the exclusive Heath 3x3 display of all these patterns so necessary for static convergence, linearity and color demodulator phase adjustments . . . plus a clear raster that lets you adjust purity without upsetting AGC adjustments. Fifteen J-K Flip-Flops and associated gates count down from a crystal controlled oscillator, eliminating divider chain instability and adjustments.

Time-Saving Versatility. While many generators only give you one or two channel capability, the new IG-28 has variable front panel tuning for channels 2 through 6. The RF tank coil is actually etched into the circuit board for extra stability. Plus and minus going video signals are available at the turn of a front panel control. And for sync, in-circuit video or chroma problems, there's a front panel sync output. Convenient AC outlets are provided for degaussing coil, test instruments, TV set etc. Built-in gun shorting circuits and grid jacks are also included. Add any service type scope (with horizontal input) to the IG-28 and you have vectorscope display capability too. Other features include a crystal controlled sound carrier oscillator, a well regulated full wave power supply with dual primary copper-banded transformer, safe three-wire line cord, and rugged, compact Heath instrument styling. Two circuit boards and two wiring harnesses provide easy construction in about ten hours. Start enjoying the versatility you couldn't get before . . . put the remarkable new Heathkit IG-28 on your service bench now.

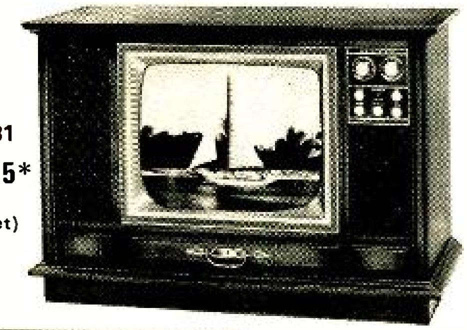
Kit IG-28, 8 lbs. **$79.95***

Look To The Leader

HEATHKIT®

Now There are 4 Heathkit Color TV's . . . All With 2-Year Picture Tube Warranty

NEW Deluxe "681" Color TV With Automatic Fine Tuning



kit GR-681
$499.95*
(less cabinet)

The new Heathkit GR-681 is the most advanced color TV on the market. A strong claim, but easy to prove. Compare the "681" against every other TV — there isn't one available for any price that has all these features. Automatic Fine Tuning on all 83 channels . . . just push a button and the factory assembled solid-state circuit takes over to automatically tune the best color picture in the industry. Push another front-panel button and the VHF channel selector rotates until you reach the desired station, automatically. Built-in cable-type remote control that allows you to turn the "681" on and off and change VHF channels without moving from your chair. Or add the optional GRA-681-6 Wireless Remote Control described below. A bridge-type low voltage power supply for superior regulation; high & low AC taps are provided to insure that the picture transmitted exactly fits the "681" screen. Automatic degaussing, 2-speed transistor UHF tuner, hi-fi sound output, two VHF antenna inputs . . . plus the built-in self-servicing aids that are standard on all Heathkit color TV's but can't be bought on any other set for any price . . . plus all the features of the famous "295" below. Compare the "681" against the others . . . and be convinced.

GRA-295-4, Mediterranean cabinet shown **$119.50***
Other cabinets from $62.95*

Deluxe "295" Color TV . . . Model GR-295

kit GR-295
now only
$449.95*
(less cabinet)

Big, Bold, Beautiful . . . and packed with features. Top quality American brand color tube with 295 sq. in. viewing area . . . new improved phosphors and low voltage supply with boosted B + for brighter, livelier color . . . automatic degaussing . . . exclusive Heath Magna-Shield . . . Automatic Color Control & Automatic Gain Control for color purity, and flutter-free pictures under all conditions . . . preassembled IF strip with 3 stages instead of the usual two . . . deluxe VHF tuner with "memory" fine tuning . . . three-way installation — wall, custom or any of the beautiful Heath factory assembled cabinets. Add to that the unique Heathkit self-servicing features like the built-in dot generator and full color photos in the comprehensive manual that let you set-up, converge and maintain the best color picture at all times, and can save you up to $200 over the life of your set in service calls. For the best color picture around, order your "295" now.

GRA-295-1, Walnut cabinet shown **$62.95***
Other cabinets from $99.95*

Deluxe "227" Color TV . . . Model GR-227

kit GR-227
now only
$399.95*
(less cabinet)

Has same high performance features and built-in servicing facilities as the GR-295, except for 227 sq. inch viewing area. The vertical swing-out chassis makes for fast, easy servicing and installation. The dynamic convergence control board can be placed so that it is easily accessible anytime you wish to "touch-up" the picture.

GRA-227-1, Walnut cabinet shown **$59.95***
Mediterranean style also available at $99.50*

Deluxe "180" Color TV . . . Model GR-180

kit GR-180
now only
$349.95*
(less cabinet)

Same high performance features and exclusive self-servicing facilities as the GR-295 except for 180 sq. inch viewing area. Feature for feature the Heathkit "180" is your best buy in deluxe color TV viewing . . . tubes alone list for over $245. For extra savings, extra beauty and convenience, add the table model cabinet and mobile cart.

GRS-180-5, table model cabinet and cart **$39.95***
Other cabinets from $24.95*

Now, Wireless Remote Control For Heathkit Color TV's

New Wireless TV Remote Control
For GR-295, GR-227 & GR-180
$69.95*

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CIRCLE NO. 74 ON READER SERVICE CARD

If you look carefully toward the right you can see a small elevated house-like structure which is one of the active repeater stations of Columbia Basin Microwave in Ephrata, Washington. This early winter photo gives an indication of the difficulty in traveling to the station for maintenance. The building construction is unique in order to permit access even when the snow reaches its peak winter depth.

radio mirrors FOR COMMUNICATIONS

By RAY D. THROWER /Field Services Manager, Microflect Co., Inc.

Huge passive reflectors, which actually provide gain of 100 to 130 dB for u.h.f. and microwave radio-relay stations, reduce installation and operating costs and keep noise to a minimum.

COMMUNICATIONS engineers are using large radio mirrors to redirect u.h.f. and microwave radio signals over and around mountains and tall buildings which would otherwise obstruct the radio beam. The use of the radio mirror, called a "passive repeater" in the communications industry, eliminates the need for large numbers of active radio-relay stations. The passive repeaters are replacing many active repeaters (with their transmitters, receivers, and parabolic transmitting and receiving dishes) and are reducing the cost of installing and operating high-density radio-relay networks.

Microwave and u.h.f. radio beams behave quite a bit like light. They won't go through buildings or mountains or any other path "obstruction." For radio system design purposes, the solution to obstructed paths or for connecting points of communications used to be the installation of an active radio-relay repeater. In some cases this can be catastrophically expensive. With new advances in the techniques of reflector technology, it is now possible to design microwave communications systems without any active mountaintop repeaters whatsoever.

Advantages of Passive Repeaters

There are quite a number of economic and technical advantages cited by systems engineers and operators who have gone to the passive-repeater philosophy of communications system design. Active radio equipment requires continual maintenance. In the winter, in some locations, active-equipment failures can mean a cold, dangerous night for a maintenance man who must get to a mountaintop site to effect repairs. Special snow vehicles, an extra-cost item, are necessary to get to most mountaintops during the winter.

The passive repeater, once installed, requires little, if any, maintenance so that technicians working on such a system never have to go to isolated mountaintop sites in treacherous weather just to replace a blown fuse. This is an important factor to safety-conscious operations managers.

Since the passive repeater requires no maintenance and no power, the cost of building an access road and running a power line to a repeater location is eliminated. The cost of access roads and power lines for an active repeater frequently exceeds the installed cost of a passive repeater. The passive repeater is also considerably less expensive than the active radio equipment.

Some typical operating and maintenance costs for an active repeater are on the order of $1600 to $5000 per year depending on the complexity of the repeater station and its accessibliity. Access road construction costs are from about $1000 per mile for simple graded roads across open country to $40,000 per mile, and more, in forested mountains. One microwave system operator reported paying $240,000 for one and one-half miles of access road.

Passive Repeaters in Use

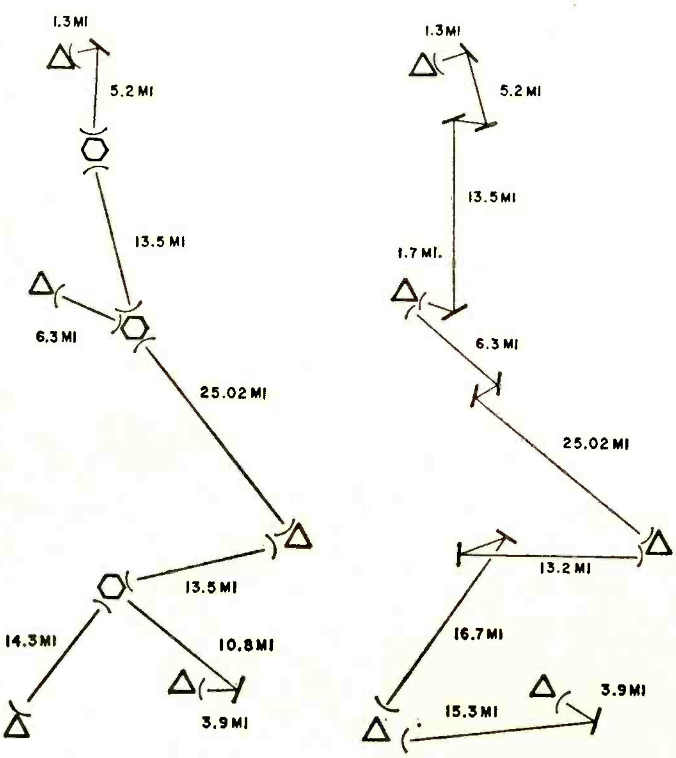
The passive repeater communications system can provide service equivalent to or better than that available from active repeater systems. Passive repeaters are being used to relay voice, video, and data communications in a multitude of systems around the world. The microwave backhaul systems from the new earth satellite stations in the Philippines, Indonesia, and Brazil use passive repeaters. A telephone company system in western U.S.A. has sixty-five passive repeaters. A 7-GHz system under construction in Iran will have 15 passive repeaters. The microwave backhaul link from the satellite earth station in Iran will also use a passive repeater. On the Island of Oahu, Hawaii, there are no

This passive repeater was installed high in the mountains of Glacier National Park, in Montana, for a large microwave radio telephone system.

less than twelve passive repeaters in four different systems.

The passive repeater is being used in greater numbers than ever before in communications systems operated by oil pipelines, railroads, military and civil government agencies, and common carriers. All types of modulation are used in these systems.

Fig. 1. Two methods of laying out a 600-voice channel, 6-GHz microwave telephone system being installed in western Oregon. System at the left uses active repeaters and seven sets of frequencies while system at the right uses passive repeaters and four sets of frequencies. Note that three active repeaters were eliminated at the right. Not only does this reduce the installation and maintenance costs, but a system noise reduction of 3 dB can be realized. Curved lines below are parabolic dishes of active repeaters; straight lines are passive reflectors.

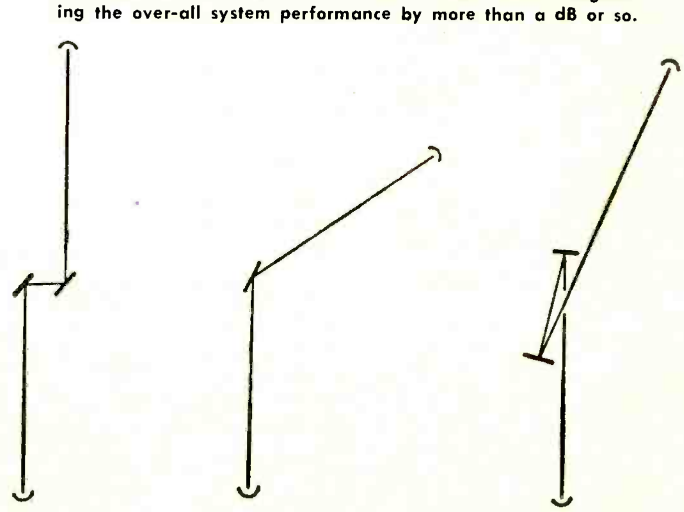


Active radio-relay repeaters contribute and amplify noise as well as the desired signal. Since the passive repeater provides passive "gain," rather than electronically amplified gain, it contributes no noise to the operating system. Active repeaters also produce intermodulation products in the radio-relay baseband. These intermodulation products are the result of the undesired mixing of different frequencies within the receiver or transmission lines and result in a gradual degradation of the information to be relayed. The radio mirror, being a passive device, contributes no intermodulation products to the signal.

What About Gain?

One thing that surprises most people is the fact that a passive repeater has gain. The question is always asked, "Gain, out of a flat surface? How can that be?" Gain has to be defined. It is generally accepted to mean an increase in level over a predetermined level. There are two types

Fig. 2. Single reflectors are used for turn angles of up to 135°, as shown at the center. For greater angles, double reflectors, as shown at left and right, are used. Spacing between the two reflectors is not extremely critical. Depending on operating frequency and reflector size, the spacing may be from under 100 feet to over a mile or more without degrading the over-all system performance by more than a dB or so.



of gain available. One is by *electronic amplification;* the other is by *aperture amplification.* For electronic amplification, power must be applied or increased in order to get more gain. In aperture amplification, the aperture must be increased to get more gain.

The passive repeater really gets its gain from the aperture it projects to the incoming and outgoing radio beams. In antenna-system work (a passive repeater actually forms an extended antenna system) gain is given in reference to an *isotropic* point source; that is, a source that radiates equally in all directions. Any change from an isotropic configuration will result in more energy being radiated in one direction than in another. Therefore, there will be gain in one direction, referred to the isotropic source. The passive repeater, with its large aperture, will result in considerable gain over an isotropic point source. For example, a 40-foot by 60-foot passive repeater, with a horizontal included angle of 90° for the radio beam will have a gain of 128.5 dB at 11 gigahertz. (*A somewhat smaller reflector, shown on our cover, will provide a gain of about 110 dB in the 6-GHz band and 120-dB gain in the 11-GHz band.—Editor*)

Quite probably the difficulty many people have in understanding how the passive repeater, a flat surface, can have gain relates back to the common misconception about parabolic antennas. It is commonly believed that it is the focusing characteristics of the parabolic antenna that gives it its gain. Therefore, goes the faulty conclusion, how can the passive repeater have gain? The truth is, it isn't focusing that gives a parabola its gain; it is its larger projected aperture. The focusing is a convenient means of transition from a large aperture (the dish) to a small aperture (the feed device). And since it is projected aperture that provides gain, rather than focusing, the passive repeater with its larger aperture will provide high gain that can be calculated and measured reliably. A check of the method of determining antenna gain in any antenna engineering handbook will show that focusing does not enter into the basic gain calculation.

Projected aperture is the effective "window" of energy seen by the antenna at the active terminal as it views the passive repeater. The passive repeater also sees the antenna as a "window" of energy. If the two are far enough away from one another, they will appear to each other as essentially point sources.

Curing Fading

Passive repeaters have been installed to cure fading of microwave signals due to unwanted ground reflections (multipath propagation) or ducting conditions. Installation of the passive repeater provides several advantages in a fading path. First, it offers angular discrimination to unwanted signals that might occur where the path goes over highly reflective terrain, such as flat land or water or even cloud or fog layers. Since the angle of reflection is equal to the angle of incidence, any unwanted signals being received from an angle other than the desired angle will be redirected off path and the magnitude of potential interference will be reduced.

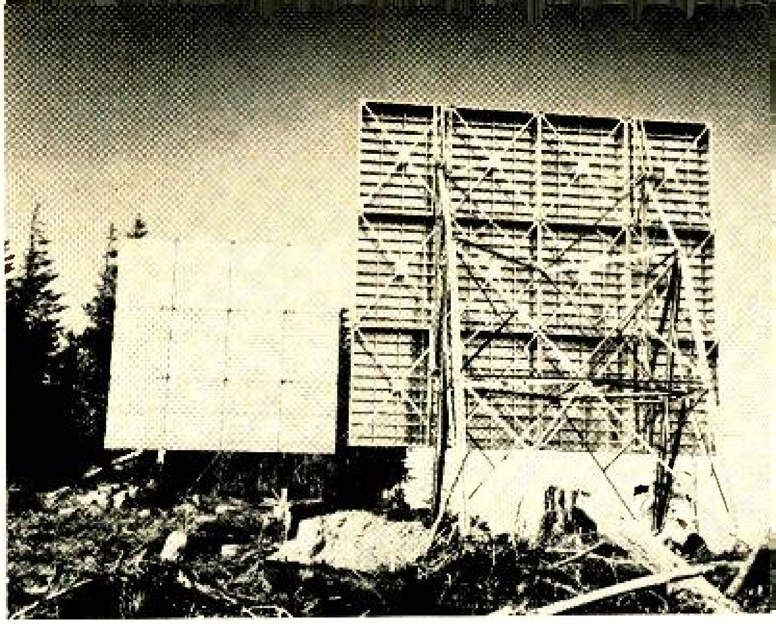
When there is ducting-type fading, the installation of a passive repeater can change the angle at which the microwave beam travels through the duct layer so that it is not so subject to being ducted off path. The sharper the angle at which the beam cuts through a duct layer, the less opportunity there is for the beam to be ducted away from the path.

Installation of the passive repeater actually can change the path geometry to such a degree that the problems causing the fading may be done away with entirely.

Engineers who design communications systems with passive repeaters have a different engineering philosophy than the engineers who put active repeaters on mountaintops. Quite a number of systems have been reconfigured to eliminate mountaintop active equipment, as shown in Fig. 1. Originally, this system, installed in western Oregon, was to have three active repeaters to connect the various communities. However, the engineers working on the system design decided to use a number of passive repeaters instead. By so doing they were able to do away with the need for three active repeaters in the 600-voice-channel common-carrier microwave system. The system has been partially completed and is operating according to design specifications.

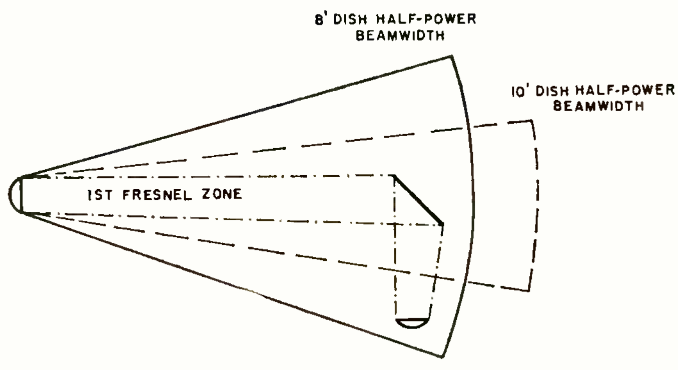
Another advantage derived is that frequency congestion in a given area is reduced by using a passive repeater. The all-active arrangement at the left in Fig. 1 would have required seven sets of frequencies where the passive-repeater system at the right will require only four sets of frequencies. This is a critical consideration where an area is approaching saturation of the frequency spectrum.

Single passive repeaters are used where the angle to be turned, the horizontal included angle, is 135° or less. When larger angles are to be turned, the effective aperture of a single passive repeater would be small and inefficient so double passive repeaters are used to achieve high aperture efficiency (Fig. 2). (*Continued on page* 66)

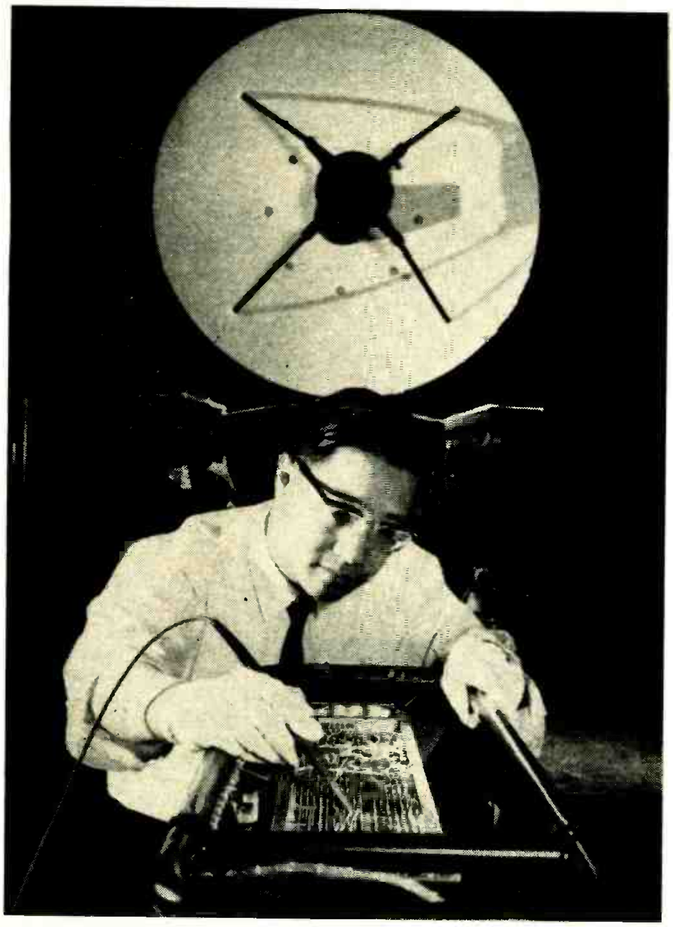


Double passive repeaters are used when the turn angle for the microwave beam exceeds about 135 degrees. Each of these reflectors is 30 by 32 ft in size. One reflector receives energy from a 6-GHz telephone company radio terminal some 25 miles away and the other redirects as many as 600 simultaneous phone conversations to a receiving station about 6½ miles away.

Fig. 3. The passive reflector need not reflect all the energy between the half-power points but merely the energy in the first Fresnel zone. The half-power points may be a mile or more apart after a distance of 30 miles while the radius of the first Fresnel zone at 30 miles with the energy being redirected for another 4 miles is only about 55 ft at 6 GHz. A reflector larger than this would reflect energy in the second Fresnel zone, which would be out-of-phase and cause destructive interference. By redirecting even a portion of the energy in the first Fresnel zone, it is possible to obtain practical gains of 100 to 130 dB. Plane reflectors are more efficient and less expensive than back-to-back parabolas.



RECENT DEVELOPMENTS IN ELECTRONICS

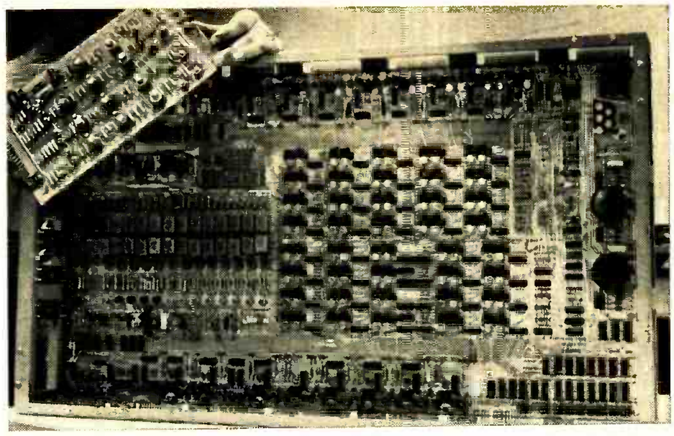


Airborne Electronics Spots Rich Ore Deposit. (Top left) High-energy pulses from an aircraft were recently used to locate a rich ore deposit in Canada. A new silver-zinc-copper ore-body was found in the Uchi Lake area of northwestern Ontario. The airborne electromagnetic prospecting system produces powerful pulses in a wire loop surrounding the low-flying aircraft. The radiated energy penetrates up to 500 feet into the subsurface of the land below and creates eddy currents that decay between pulses. The character of the decay is measured by sensitive receiving coils housed in a "bird" towed beneath the plane. Since ore is more conductive than its surroundings, it can be detected as an irregularity in the received energy. An airborne proton magnetometer sensor is also housed in the "stinger" extending from the rear of the plane. The magnetic measurements also help to locate anomalies in the subsurface. At the same time, cameras view through the former bomb-bay the terrain over which the plane flies. The survey system was developed by Barringer Research (Toronto).

Rendezvous Radar for Apollo Lunar Module. (Center) The radar being checked out here is designed to guide our Apollo lunar module back to the command/service module in lunar orbit for the return to Earth after a Moon landing. This rendezvous radar, located in the lunar module, works with a transponder in the command/service module. The radar measures velocity, angle, and range between the two spacecraft and simultaneously displays this data to the astronauts and feeds it into the spacecraft guidance system. An additional radar, known as the landing radar, will provide measurements of altitude and velocity with respect to the lunar surface. This will allow the astronauts to know exactly where they are relative to the planned point of lunar touchdown. Other radars on the Earth track the boosters and spacecraft from lift-off to touchdown. These radars were developed by RCA.

Police Radios Are Getting Smaller. (Left) A new two-way police radio that's almost small enough to be worn on the wrist is shown here. The unit is just a little larger than a pack of cigarettes and weighs under a pound. Power output is 100 mW and the Handie-Talkie makes use of IC's in its separate transmitter and receiver sections to achieve its small size. The FM radio operates in the 150 to 174 MHz public-service band and uses a rechargeable nickel-cadmium battery. Only very slightly larger is another model which produces an r.f. output power of 1.8 watts with a little heavier battery. So impressed with the latter Motorola unit was the N.Y. City Police Dept. that they purchased the first lot of over 600 of the new radios at a cost of $740 each. The Department plans to purchase 2230 more units next year. The radio is about half the size and weight of present models carried by patrolmen.

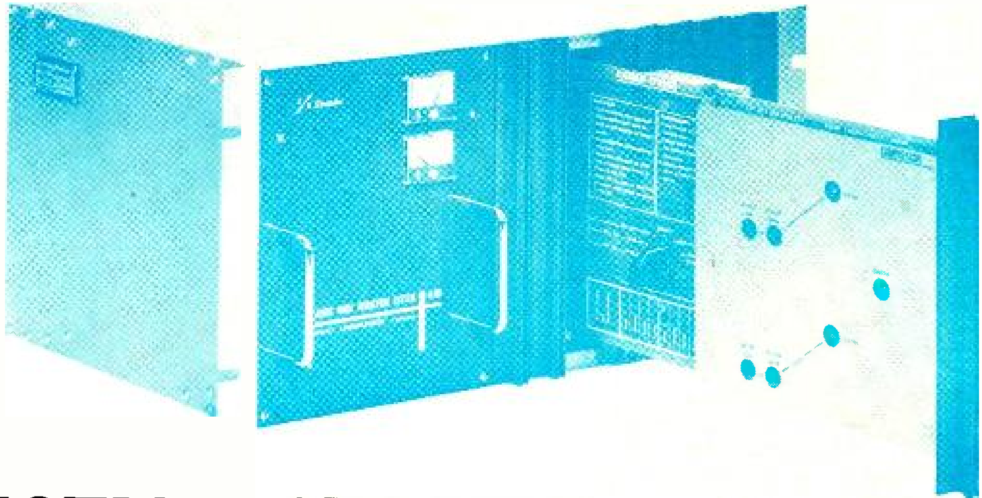
Printed Circuits Are Getting Bigger. (Top right) Just four of these large PC boards comprise most of the circuitry in the new Westinghouse Prodac 2000 computer. Replacing the more familiar small circuit boards at the top left, the large 16 by 25-inch plug-in boards handle the input/output, memory, and arithmetic functions. This arrangement should simplify trouble-shooting since it will not be necessary to search for hours to find one of the smaller boards that may have a fault. If something goes wrong, a spare big board can be plugged in to keep the computer operating while the defective board is returned for repairs. It's like plugging in an entire new motor to keep your car running while the defective one is sent back for repairs.



Sensor Protects Front-Line Troops. (Center) This pocket-sized electronic sensor helps protect our troops against camouflaged or nighttime infiltration. The compact device, when implanted in the ground, detects vibrations made by moving humans or vehicles up to 75 feet away. A coded warning signal is then transmitted to a receiver that can be located from one-fifth to five miles away, depending on terrain. Four mercury batteries power the unit for about two years—sensing but not sending an alarm. The warning signal can be transmitted for 4000 hours. Unit was developed by Sylvania for military use.

TV Camera for the Moon. (Below left) This 7-lb camera is one of five that will be carried by our astronauts when they land on the Moon. The camera can operate in the vacuum of space or in the 100-percent oxygen atmosphere of a spacecraft; it can withstand temperatures from 250° F during the lunar day to −300° F at night. Because of the special secondary electron conduction imaging tube used, the Westinghouse TV camera is able to produce clear pictures during the lunar night using only the very small amount of light reflected from the earth.

Multiplexed Entertainment System for Superjet. (Below right) When the new Boeing 747 goes into service late this year, its 360 passengers will be able to use a new audio entertainment system whose quality approaches that of a good home hi-fi setup. Response of the system exceeds the 5-kHz top limits of the air-tube stethoscope-type stereo headsets used. There are no less than 15 channels of audio (10 from a master tape deck, 4 for movie audio, 1 for passenger override address) that are carried to all seats over a single coaxial cable. The audio is sequentially sampled at a 25-kHz rate using a time-division multiplexing technique. Additional pulses are put into the line to control the reading light and call the attendant. The new system, developed under a $37-million contract by Instrument Systems Corp., not only transmits high-quality sound but also eliminates over 25 miles of wire and over 500 lbs of weight.



The professional Model A301 Dolby noise-reduction unit is designed for stereo tape mastering and duplicating. One of the compressor modules has been withdrawn from rack-mountable enclosure in this view. Cost of unit shown is around $1500.

THE DOLBY NOISE-REDUCTION SYSTEM—*its impact on recording*

By JOHN EARGLE

This system, now in use at hundreds of recording studios, improves signal-to-noise by 10-15 dB. The result is better discs made from the master tapes which are quieter and have greater dynamic range.

PERHAPS no other invention in recent years has caused so much talk in the phonograph-record industry as the *Dolby* system. One by one, record companies around the world are switching over to it, not only as a means of generating high-quality master tape copies for their international affiliates but for original recording as well. The *Dolby* A301 noise-reduction unit has been around now for about two years, and after an initial skepticism on the part of many record companies the unit has now been accepted. There are close to 300 units now in use at over 90 companies throughout the world.

Noise and Dynamic Range

First of all, why is there a need for noise reduction? The range of sound levels normally encountered in daily life is far greater than the dynamic ranges which even the finest professional tape machines can handle. It is a characteristic of all audio equipment to produce distortion at one extreme of its operation, that is, when one tries to put *too much* signal on the tape. At the low-level extreme, there is the old bugaboo of tape hiss.

A beautiful analogy exists between recording sound and taking pictures. Just as a photographer selects a film speed and a combination of shutter speed and lens opening to allow him to record the maximum information on a piece of film, the skillful engineer sets his recording level in very much the same way. He tries to adjust his level so that the loudest passages will not overload and also that tape hiss will not intrude upon the softer passages.

Fig. 1 illustrates the photographer's, as well as the recording engineer's, dilemma. This is a *gamma* curve, and it is a plot of the light density of a piece of photographic film as a function of its exposure to light. The photographer wants to keep his average light values centered on the *B* point so that he can make good use of the straight line or most linear portion of the curve between *A* and *C*. If he over-exposes, he is up in the *D* area, and he will lose gradation and detail. Likewise, if he under-exposes, he will be down in the *E* area, and there again he will lose detail. With the human eye, the pupils contract in bright sunlight and open up in the dark. The eye, too, is limited in its "dynamic range", that is, the range of values that it can accept, and it must accommodate itself in much the same way that the photographer and the recording engineer make their adjustments.

For a long, long time skillful recording engineers have made their level adjustments, centering the sound-signal level around some point *B* on a curve similar to that of Fig. 1. When the music got soft and the sound level moved down toward *A* with occasional excursions into the *E* region, the engineer would *raise* the input level of his recorder to bring the sound-signal level up around *B* again. Likewise, if the music got too loud with excursions into the *D* region, he would *lower* the input level to bring the sound signal back into the straight-line portion of the curve.

After he had made the recording, he would hand-monitor the levels during playback in such a way as to provide an inverse action; that is, where he had raised the level during recording, he would now lower it on playback, and *vice versa*. Accordingly, a skillful recording engineer could record and play back a dynamic range that far exceeded the basic capabilities of his system.

There was only one rub, however. The system would not work by itself, and the engineer had to be on hand for each playback and, furthermore, had to remember every time the necessary changes had to be made in playback level. Obviously, the system leaves much to be desired because of its complete dependence upon one individual.

The next logical development was the matching together of a pair of complementary compressors and expanders. A compressor narrows or reduces the dynamic range of an audio signal, while an expander widens or increases its dynamic range.

In Fig. 2 the dashed line *A* shows the input-output response of a standard amplifier. For an increase in input, we get a corresponding increase in output. Curve *B* is the response of a compressor. Note that as the input increases, the output begins to level off somewhat. Curve *C* shows the action of an expander. Its action is the opposite of a compressor; as the input increases, the output increases by a factor greater than one.

Recording engineers attempted to match the characteristics of the compressor-expander pair so that the two circuits would tend to complement each other. The compressor would obviously be used in recording in an effort to handle maximum levels and reduce distortion. The expander would then be used in playback; the idea being to restore the over-all net gain of the system to a fixed value.

Such systems were more or less successful on certain kinds of music. However, there were some peculiar problems involving attack and recovery times which were characteristic of these arrangements. These are important parameters of any kind of compression or expansion system.

Compressors have generally been made so that they *attack*, or go into their gain-reduction action, in a matter of a few milliseconds. The reasoning here should be obvious. When you need the gain-reduction action, you need it immediately, otherwise distortion will be the result. Once the gain has been reduced, it is desirable for it to stay at its new value and not fluctuate or return to its former value too quickly. If this *recovery time* were as fast as the attack time, the ear would most certainly hear it as an unpleasant modulation of the program. Customarily, recovery time-constants in compressors may be several seconds, slow enough to insure a modulation-free action of the device.

In some respects the use of a complementary compressor-expander pair worked well. The built-in "following" action, resulting from the necessity of the expander to act on a previously compressed signal, caused no great problem. It did create a slight dynamic error in the over-all gain characteristics of the record-playback system, but for the most part this error was fairly small and would even tend to be masked by the program itself.

The big problem with this system was the "pumping" or "breathing" action, which was the raising and lowering of background noise, a natural consequence of the system operating the way it did. This action was not apparent at all times, but it could often be heard quite clearly on solo instruments, especially when playing in either high or low registers.

The foregoing method of increasing dynamic range in a recording system was never widely practiced in the recording industry. Instead, the industry looked to the manufacturers of tape machines and raw tape to come up with products which had lower inherent noise and/or higher output characteristics. This would permit recording signals with greater dynamic range. However, development in magnetic-tape technology goes along fairly slowly, and there are certain fundamental limits that simply cannot be exceeded.

Enter the Dolby System

It is at this point that Ray Dolby entered the scene, pushing the bounds of signal-to-noise range out another 10 to 15 decibels. Dolby's method of noise reduction is essentially a compression-expansion scheme. However, it differs in several very important ways from the method outlined previously.

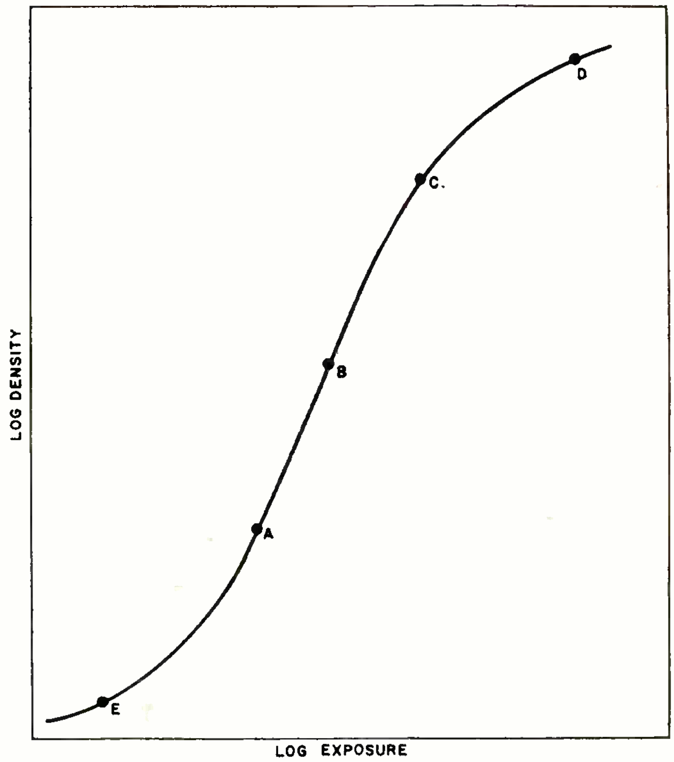
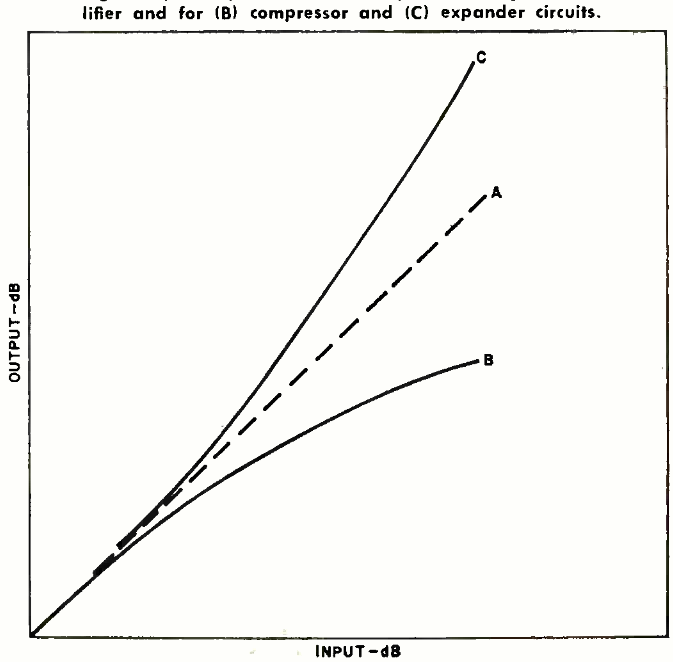


Fig. 1. Typical "gamma" curve for photographic emulsion.

First of all, he deals with the problem of "breathing" by dividing the recorded spectrum up into four bands, each of which is operated upon separately. For each audio channel there are four compressors working during recording and four expanders working during playback. He further minimized the "breathing" problem by using much shorter time-constants in both the compressors and expanders. Finally, he operates *only on soft passages* of the music, not on loud ones as the previous scheme did. We will see presently that there is a great benefit to be derived from this.

Fig. 3 shows the complementary compression-expansion curves of a typical pair in a *Dolby* system. Note that at input levels in the neighborhood of 0 dB there is little compression or expansion action. As the input level is reduced the compressor section tends toward an increased gain of

Fig. 2. Input-output curves for (A) typical fixed-gain amplifier and for (B) compressor and (C) expander circuits.



10 dB, thus allowing the recorded signal to ride 10-dB higher above the inherent noise level of the recorder. During playback, the low-level passages are reduced a corresponding 10 dB in level, an action which restores the music to where it belongs and at the same time depresses the noise level of the recorder by 10 dB.

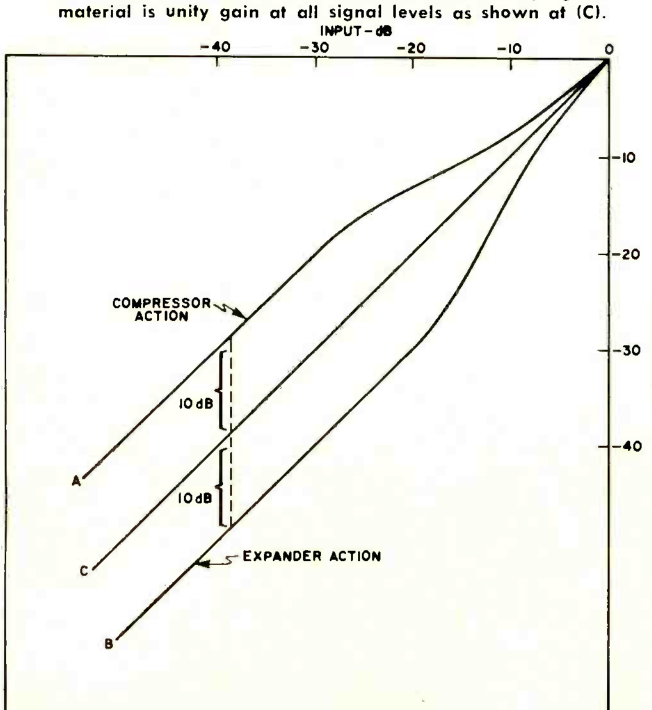
Multiply this kind of action by four, a compressor-expander pair is used in each of four audio bands, and the result is a 10-dB improvement in signal-to-noise ratio with no audible side effects. The four audio bands are: 30 to 90 Hz, 90 to 3000 Hz, 3000 to 9000 Hz, and finally 9000 to 15,000 Hz. Incidentally, the compression-expansion ratio for the 9000 to 15,000-Hz band is 15 dB instead of the 10-dB characteristic used for the other three bands. Dolby's choice of a 15-dB action above 9000 Hz complements the noise spectrum of magnetic tape better than a 10-dB action.

We mentioned earlier that Dolby's decision to operate on low-level music was a fortunate one. Among other things, this means that at the normal reference levels used for calibrating tape machines and other transfer systems, the *Dolby* units are acting like straight unity-gain amplifiers. Thus, calibration procedures are vastly simplified; indeed they are almost foolproof. Furthermore, relegating the compression-expansion action to low-level music minimizes the "following" effect referred to earlier. Low-level music generally is characterized by fairly sustained passages with a minimum of transient action. Thus, the degree of dynamic error which results from the "following" action is minimized. At high levels there is no "following" action at all and, consequently, no dynamic error.

The actual circuitry involved in the *Dolby* process is quite complicated. We will mention only that there are a number of circuit developments in the unit which are the subject of patent applications.

One of the more unique developments in the circuitry is the control of overshoot when the unit goes from very soft to maximum levels. For a pair of *Dolby* processors, the total overshoot will not exceed 2 dB, a value easily small enough to be masked by the transient nature of the program itself which may have caused the overshoot. Another feature of the system is the unique way of insuring precise tracking between the recording and playback functions. As many as six pairs of compressors and expanders have been rigged up in series and the maximum error between input and output has been observed not to exceed ½ dB.

Fig. 3. Dolby complementary compression-expansion action. During recording (A) compression occurs; during playback (B) expansion takes place. The total net effect on the program material is unity gain at all signal levels as shown at (C).



Something for Nothing?

But there are still skeptics. Everybody knows that you can't get something for nothing, and many of the skeptics feel that the *Dolby* system must be doing something bad to recorded music. But surprisingly enough, nobody can hear it doing anything bad. Like all noise-reduction systems, it makes use of the fact that music, along with most other kinds of information, is fairly redundant, and the trade-off that Dolby makes is between noise and the accuracy of musical envelope transmission. In other words, the 10-dB improvement in signal-to-noise ratio has been bought at the expense of the "following" action referred to earlier, the fact that it takes a finite amount of time for the playback unit to "read" the processed recording and determine what has to be done to it in order to restore it to its original form. Since music is so redundant in time, the ear can apparently tolerate these small errors and even ignore them. Furthermore, the ear has errors of its own. It has its own built-in reaction times to sudden changes in volume, very much like the reaction time of the eye. Thus, there is a good bit of physiological and even psychoacoustical masking going on here.

When many people claim that they hear the *Dolby* system working, what they are hearing is, in effect, the absence of certain inherent defects which they may have become so accustomed to previously. It is surprising how many people who should know better, actually favor small amounts of distortion on high-level passages. Why? Probably because they are simply used to it and expect it to happen. When it doesn't happen, they feel that something isn't right. So there is still some missonary work to be done in showing people what really good, clean sound is.

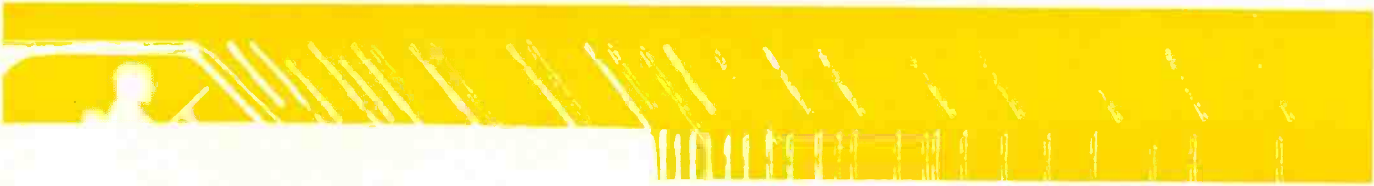
With the dramatic reduction of distortion and noise which the *Dolby* system gives us, the burden now is on record manufacturers to improve their processes so that the noises produced during metal plating and those inherent in vinyl formulations can be reduced. A master lacquer, cut from a *Dolby*-processed tape, is indeed almost eerie in its superquiet surfaces. If it is carefully processed, it can yield pressings which are almost as good and this should be the goal of the record industry.

Other Uses in the Home

Ultimately, it could be possible to employ a *Dolby* playback system in the home on which either processed records or processed pre-recorded tapes would be played. The record companies would simply have to cut their master lacquers directly from a *Dolby* master tape or make their pre-recorded tapes from the same thing. These products would then be played back in the home over systems containing the equivalent circuitry of the playback portion of the *Dolby* A301 unit. Such a device might look like a small preamplifier with perhaps two knobs on it and a meter for calibration, inserted between the conventional preamp and power amplifiers of a standard system. It is hard to tell how much a device like this would cost but it could be quite inexpensive.

At least one manufacturer of consumer high-fidelity products, *KLH*, is marketing a tape recorder with a modified *Dolby* record-playback function. The scheme is not as sophisticated as the professional units but it does work surprisingly well. It yields a drastic reduction in tape hiss and enables the user to make really good 3¾ in/s tape copies.

This is but the first consumer application. Doubtless we can look forward to a more sophisticated approach, hopefully a four-band scheme like the present professional units, for the ultimate in reproduced sound in the home. ▲



Electronic Speed Control

for the '69 Ford

By FRED W. HOLDER / Bendix Field Eng. Corp.

Electronic memory using transistors and MOSFET's permits almost instantaneous speed memorization and single-wire transmission of control signals from the steering wheel to the system's computer.

TOOLING along an open highway, it's nice to relax and enjoy the pleasures of driving. Driving is even more fun when the operator doesn't have to worry about speed changes and such.

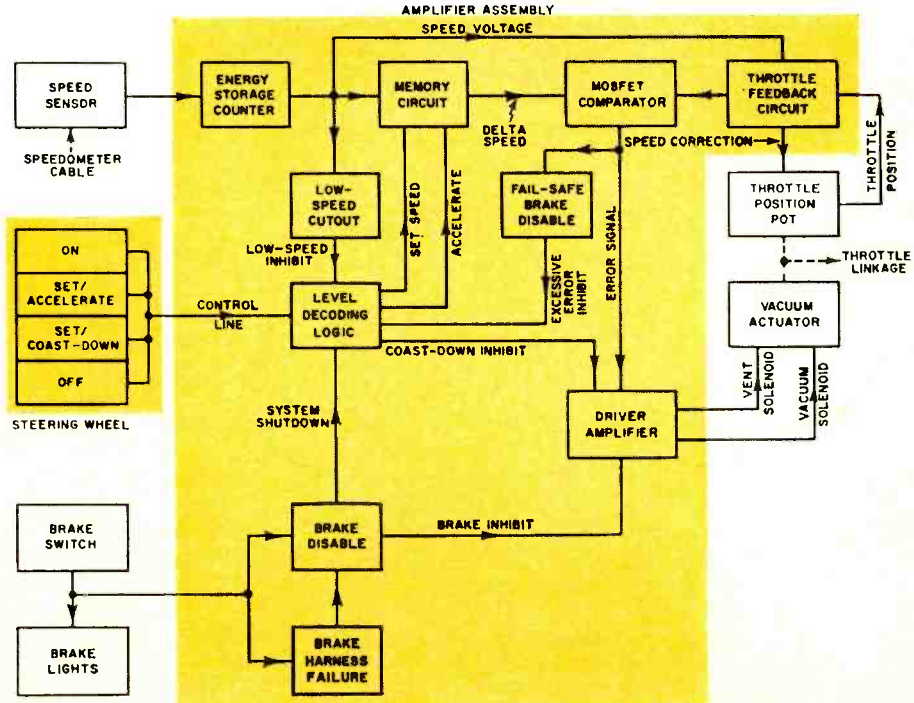
A new automatic speed control, developed by the Automotive Division of *Bendix Corp.*, makes moving along a highway at a constant rate of speed as simple as pushing a button. It utilizes an electronic memory with almost instantaneous speed memorization and single-wire transmission of control signals from the steering wheel to a computer as a vehicle-velocity control device. The system is now available as an optional item on all 1969 *Ford* and *Mercury* models.

Operator controls for the system (Fig. 1) are located on the steering wheel. By selecting and depressing one of four push-buttons, the operator transmits one of five possible commands over the single wire running from the switching circuits to the system's computer. He may turn the system "on" or "off," set the desired speed, or order acceleration or deceleration without removing his hands from the steering wheel.

In addition to the operator controls located on the steering wheel, there are three other assemblies: a speed sensor, a throttle actuator, and an amplifier (or electronic computer). Briefly, system operation may be summarized as follows.

The speed sensor, driven by the speedometer cable, produces pulses at a rate proportional to shaft rotation; this rate represents vehicle speed. These pulse are rectified and converted to a d.c. voltage level representing vehicle speed at any given instant. This data is held in an energy-storage counter. An operator-ordered "command-speed" signal impresses the vehicle speed voltage across a low-leakage memory capacitor (in one gate of a metal oxide silicon field-effect transistor, MOSFET, comparator). A feedback potentiometer, mechanically controlled by the throttle linkage, provides the throttle position signal to the other gate of the MOSFET comparator. Any variation in vehicle speed is compared to the

Fig. 1. Block diagram of Ford speed-control system shows the interconnections of the major functional circuits and various assemblies.



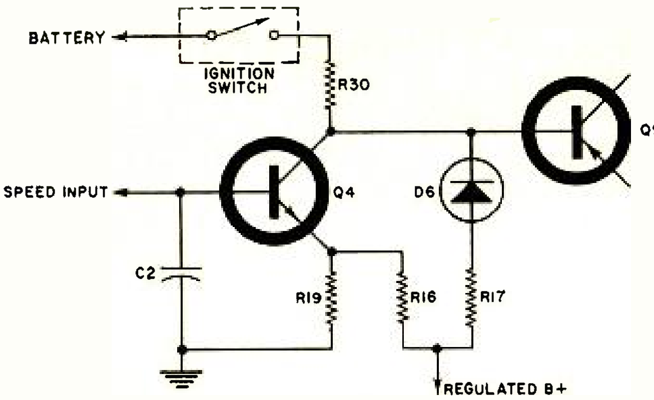


Fig. 2. Low-speed cutout circuit changes gain at threshold speed.

throttle position signal. The resulting error signal is amplified and used to drive solenoid valves in the throttle actuator.

The level of the error signal determines whether one valve opens to allow vacuum to be drawn in the actuator chamber or another valve opens to allow atmospheric pressure to enter the chamber. By controlling these two valves, the chamber pressure may be set to overcome the spring pressure and maintain any desired position of the chamber diaphragm within the limits of its stroke. This diaphragm controls the throttle linkage.

For purposes of detailed analysis, the electronic circuits of the system may be divided into several sections. Let's take a look at each of these sections and see how they work.

Low-Speed Cutout

It is important to consider the low-speed cutout circuit first, because the system cannot be activated unless the vehicle speed is greater than the threshold of the system. If we assume that the vehicle speed is above threshold, then the speed voltage applied to the base of multipurpose transistor amplifier *Q*4 (Fig. 2) will be sufficiently positive to lower the collector voltage enough to arm transistor *Q*9. Also, at this speed, *Q*4's collector voltage is low enough to forward-bias diode *D*6, resulting in a paralleling effect between resistors *R*17 and *R*30. The gain of *Q*4 is reduced from about 40 to unity by this action. This change in gain is necessary to limit the sensitivity of the amplifier once the vehicle has attained threshold speed, because *Q*4 has another function to perform after threshold speed is acquired. This function will be discussed further when we investigate the throttle feedback circuit.

Level Switching & Decoding Logic

When the operator turns on the ignition switch (Fig. 3), battery power is applied to all of the electronic circuits, except the decoding logic and the driver amplifier. To energize these latter circuits, the operator must press the "on" button located on the steering wheel. This action completes the circuit to energize the coil of relay *RL*4 through the horn relay coil and resistors *R*37, *R*39, and *R*40. The current through this path is sufficient to energize *RL*4, but will not operate the horn. The contacts on relay *RL*4 provide current for a holding circuit and apply power to the decoding logic. *RL*4 remains latched until the ignition switch is turned "off" or the speed-control system "off" button is depressed.

If vehicle speed is above threshold, the operator may now activate the system and set the acquired vehicle speed into the system memory by tapping either the "Set/Accelerate" or the "Set/Coast-Down" switch on the steering wheel. Assume the operator taps the "Set/Accelerate" switch so that a circuit is momentarily completed through resistors *RA* and *R*37. The resulting voltage on the control line is too positive to turn on *Q*15. But, because the emitter of *Q*14 is at a higher positive potential, it is low enough to allow *Q*14 to saturate. Current from the collector of *Q*14 passes through *D*8 to energize the coil of relay *RL*2, closing its latching contacts and applying power to the driver amplifiers. As long as the vehicle speed remains above threshold, *Q*9 will be conductive and *RL*2 will remain latched. The system returns to normal when the "off" button is depressed or the brake is operated.

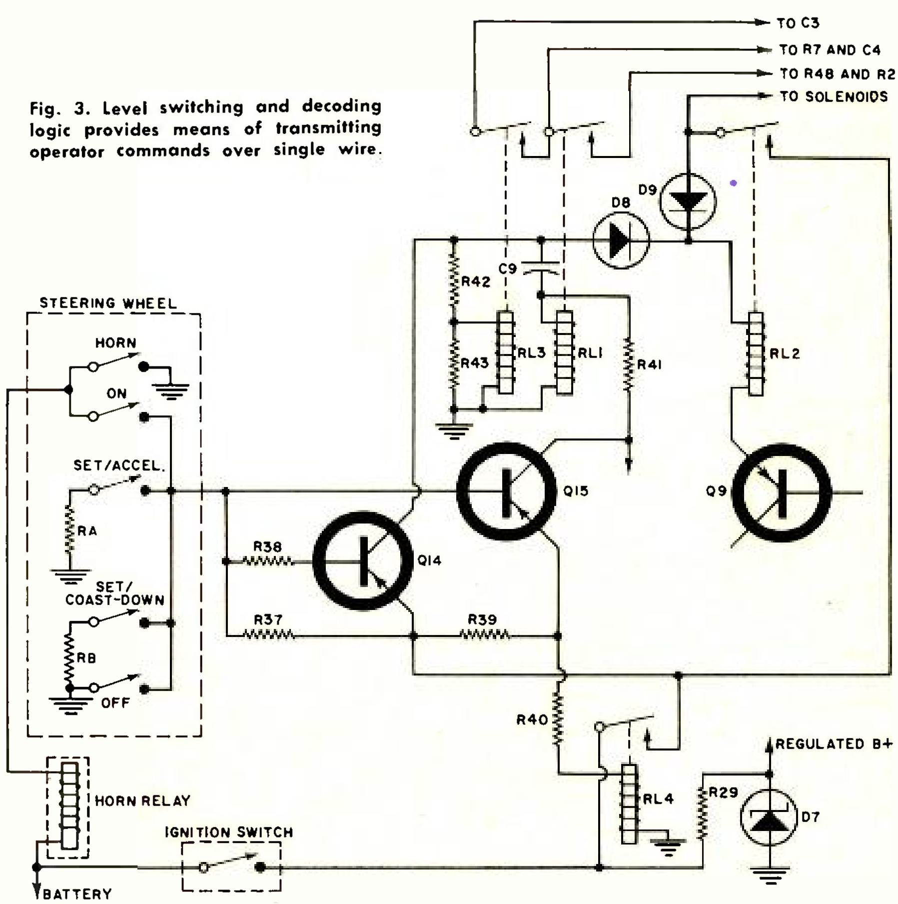
The initial voltage pulse from *Q*14 also energizes the coils of relays *RL*1 and *RL*3. Once capacitor *C*9 is charged, however, relay *RL*1 is deenergized. When the "Set/Accelerate" switch opens, another voltage pulse passes through *C*9 and again energizes *RL*1. Because the voltage across *RL*3 is less than the voltage across *RL*1 by the drop across *R*42, its contacts open before those of *RL*1. If the operator had tapped the "Set/Coast-Down" switch, a similar reaction would have occurred. In addition, *Q*15 would have turned on (momentarily) and cut off the driver amplifier while speed was being entered into the memory.

The "off" switch, when closed, grounds the control line. This causes *Q*15 to drop most of the supply voltage across *R*39, causing *RL*4 to deenergize, thus deenergizing *RL*2.

Speed Sensing

The speed-sensing circuit (Fig. 4) uses a variable-reluctance, alternating-current-type speed sensor which is driven by the speedometer cable and an energy storage counter. The operation of this circuit is very similar to that of a standard voltage doubler except that *C*1 is much smaller than *C*2. Voltage pulses from the speed sensor are rectified by temperature-compensating diode *D*1. These negative pulses are

Fig. 3. Level switching and decoding logic provides means of transmitting operator commands over single wire.



proportional to the vehicle's road speed. The negative pulses turn off transistor Q1 so that a positive pulse of fixed amplitude is applied to the counter circuit made up of C1, C2, D2, and D3. The resulting d.c. voltage level (dependent on the vehicle's road speed) is stored in C2. Compensation for the nonlinearity of the charge and discharge characteristics of this circuit are handled in the throttle feedback circuit.

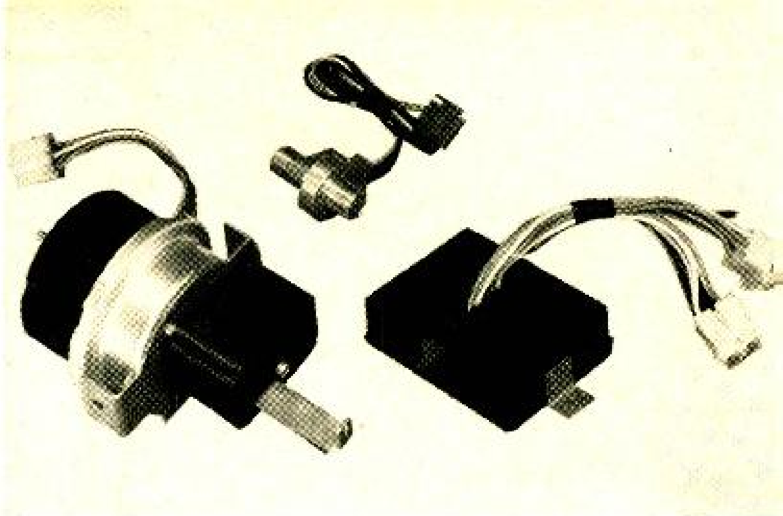
Memory and Comparator

The memory and comparator circuit (Fig. 5) stores information concerning the desired cruising speed and compares this information with actual vehicle speed and throttle position to generate an error signal. A low-leakage memory capacitor, C3, is connected between C2 and the gate of MOSFET Q2. MOSFET's are characterized by their extremely high gate impedance so that, for all practical purposes, C3 is open circuited at the gate of Q2. When the operator taps the "Set/Accelerate" switch, relay contacts *RL*1 and *RL*3 momentarily close and a voltage equal to that across C2, less the voltage at the junction of *R*26 and *R*48, is impressed across C3. The voltage at the gate of Q2 now follows the voltage across C2. If vehicle speed remains constant after the relay contacts open, the voltage at the gate of Q2 is equal to the voltage at the junction of *R*26 and *R*48. Any change in vehicle speed, however, causes a proportional change in the voltage at the gate of Q2.

Q2 and Q3 and their bias components function as a comparator for vehicle speed and throttle position. The throttle position input from the feedback circuit is applied to the gate of Q3. The error signal output of the comparator is taken from the drain terminal of Q2 and applied to the base of transistors Q5 and Q6 in the fail-safe brake disable circuit and the driver amplifier.

If the operator wishes to have the speed-control system make the vehicle accelerate, he depresses the "Set/Accelerate" switch and holds it down until the vehicle reaches the desired speed. In this mode, the vehicle accelerates at a rate of about two feet per second per second. Once the desired speed is reached, the operator releases the "Set/Accelerate" switch and enters the new speed into the memory. While the "Set/Accelerate" switch is held down, Q14 remains saturated and *RL*3 remains closed. *RL*1 momentarily closes and then opens when C9 (Fig. 3) is charged.

When *RL*1 opens, the gate of Q2 and capacitors C3 and C4 are connected to ground through an extremely large resistor, *R*7. The charge on C3 and C4 slowly leaks to ground potential, causing an increasing error signal and a corresponding increase in vehicle speed. The increased vehicle speed results in a higher d.c. voltage level across C2. This



1969 Ford speed-control system's three major assemblies; throttle actuator at left, speed sensor center, and amplifier right.

increase in voltage is transferred through C3 and C4 to develop a voltage across *R*7 that is proportional to the rate of change of the voltage across C2, which is, of course, proportional to acceleration. When the "Set/Accelerate" switch is released, *RL*1 again closes and sets the new vehicle speed into memory capacitor C3.

Driver Amplifier

The driver amplifier (Fig. 6) converts the error signal from the comparator into two separate driver signals to control the solenoid valves in the vacuum attenuator. The signal from Q2 is fed to the base of transistor Q6, which is connected differentially to Q7. This configuration increase the gain of Q6 and provides temperature compensation. The amplified error signal is applied to the base of Q8, along with negative feedback from Q11 through the parallel combination *R*31 and C7, brake-disable inputs from the brake-disable circuit, and a decelerate inhibit signal from the collector of Q15. Normally, these latter two inputs are inactive.

The amplified and inverted signal from Q8 drives Q11 which, in turn, drives both Q12 and Q13. The interconnection of Q11, Q12, and Q13 is such that Q13 must saturate before Q12 can conduct. The error signal must also exceed the forward conduction voltage of D15, plus the saturation voltage of Q13 and the base-to-emitter forward voltage of Q12 before Q12 can conduct. As a result, an increasing error signal will first cause Q13 to conduct, energize the vent solenoid, and close the normally open vent valve. A further increase in error voltage will turn on Q12, energize the vacuum solenoid, open the normally closed vacuum valve, and decrease the pressure in the actuator chamber. An increasing

Fig. 4. Speed sensing circuit converts a.c. pulses to d.c.

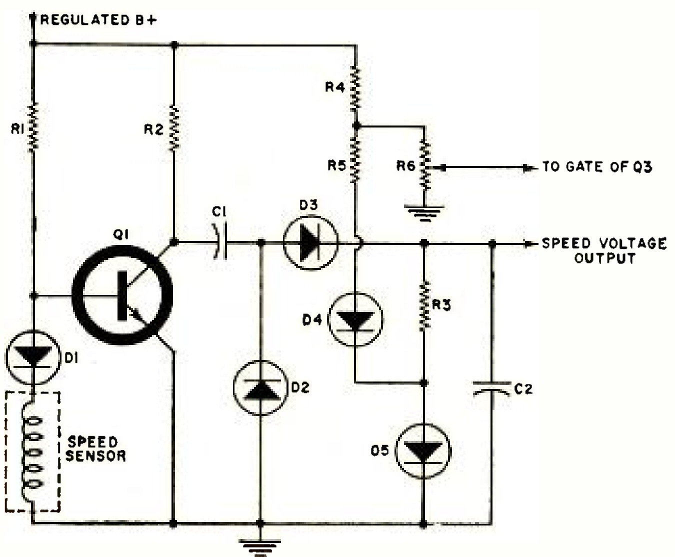
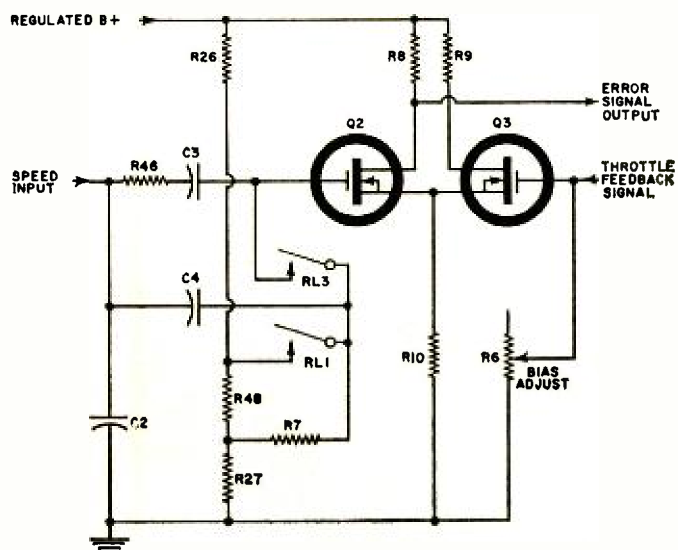


Fig. 5. Memory and comparator circuit uses MOSFET's.



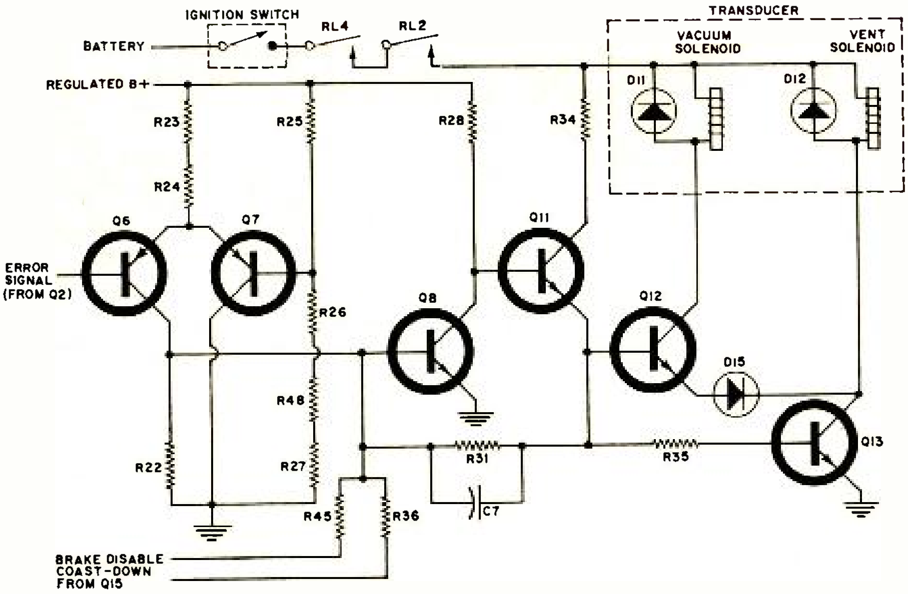


Fig. 6. Driver amplifier converts error signal from comparator into separate driver signals to control solenoids.

(positive) error signal causes increased vacuum in the actuator chamber and represents a command for increased throttle opening and, of course, increased speed. A decreasing error signal will reverse this process, that is, it decreases the throttle opening and reduces speed.

When the "Set/Coast-Down" switch is depressed and held down, transistors Q14 and Q15 (shown in Fig. 3) are turned on and relays RL1 and RL3 are energized, a positive signal from the collector of Q15 is applied to the base of Q8 through R36. Transistor Q8 saturates, turning off transistors Q11, Q12, and Q13. The vacuum valve closes and the vent valve opens, releasing the throttle so that the vehicle slows down. When the "Set/Coast-Down" switch is released, RL1 again closes (momentarily) and sets the new vehicle speed into the memory capacitor C3 (shown in Fig. 5). The system begins to operate at the new speed.

Throttle Feedback Circuit

The throttle feedback circuit (Fig. 7) provides a speed-compensated, throttle-position signal for comparison with the system's set speed. Speed compensation is necessary because the voltage developed across C2 is not linear with speed. This is a result of the charge-storing circuit's nonlinear characteristics. By connecting multipurpose transistor Q4 across the feedback potentiometer, a means was provided to vary the throttle feedback signal in response to vehicle speed. This feature compensates for the nonlinearity of the speed counter circuit. As vehicle speed increases, Q4 becomes more conductive, decreasing the voltage across feedback potentiometer R18. This decreases the available feedback voltage. The roll-off of the throttle feedback has been made to compensate for the roll-off of the electrical signal proportional to vehicle speed.

The wiper position of R18, corresponding to engine idle, is at the midpoint of the potentiometer. By choosing R17 slightly smaller than R19, the average feedback voltage for a given wiper position will rise with increasing speed. As a result, the higher the speed memorized, the greater the average throttle opening.

When the throttle is not moving, the d.c. voltage generated by the feedback potentiometer is fed through R14 to the gate of Q3. To compensate for a moving throttle, a.c. voltage signals generated when the throttle is moving are also fed through the parallel path of C5 and R13-R14. By using a parallel circuit such as this, it was possible to prevent too rapid movement of the throttle when vehicle speed is greatly below the command speed. This feature also allows greater sensitivity of the comparator to the feedback signal as the vehicle reaches command speed.

Brake-Disable Circuits

The brake-disable circuit (Fig. 8) deactivates the system when the brakes are applied. Normally, the brake switch closes when the brakes are applied, connecting the brake-disable circuit to the positive battery voltage. This applies a positive signal through R45 to the base of Q8, driving that transistor into saturation and turning off Q11, Q12, and Q13 to release the throttle in a manner similar to coast-down. In addition, the positive voltage is applied through D10 to the base of Q9, turning off Q9 and unlatching relay RL2. This latter operation deactivates the system.

A fail-safe circuit is also provided to render the system inoperative should the brake switch become disconnected from the speed-control system. A current path is normally provided from the ignition switch through R44 and the brake lights to ground. The current flow through R44 is not sufficient to energize the lights. In the event that the brake harness becomes open, the voltage at the junction of R44, R45, and D10 will build up to the positive battery voltage and shut down the system.

A fail-safe circuit (Fig. 9) is provided as a back up to the normal brake-disable circuit in the event the brake switch fails to close when brakes are applied. An error signal from the comparator cuts off Q5 and Q10. This unlatches RL2 (Fig. 3) and deactivates the system. ▲

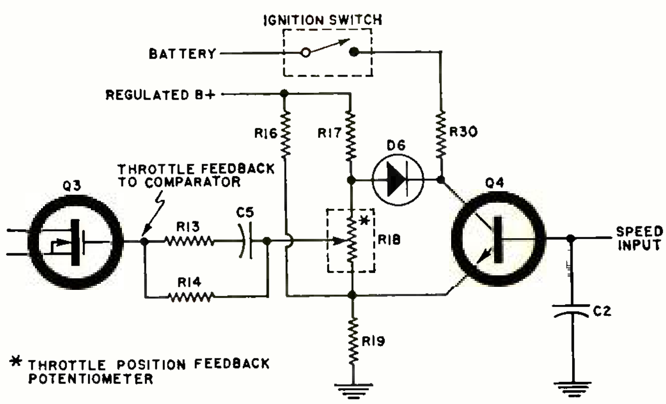


Fig. 7. Throttle feedback circuit compensates for nonlinearity by changing the voltage level as vehicle speed increases.

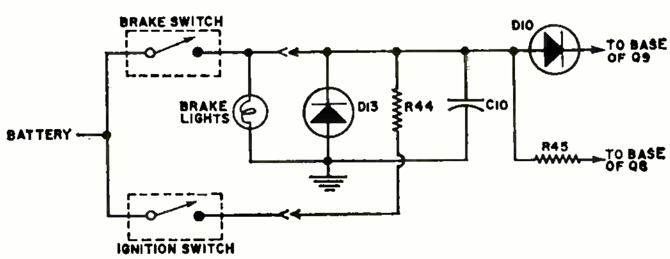
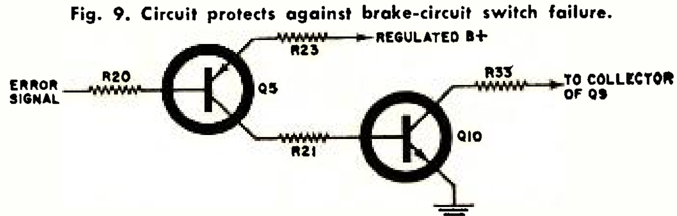
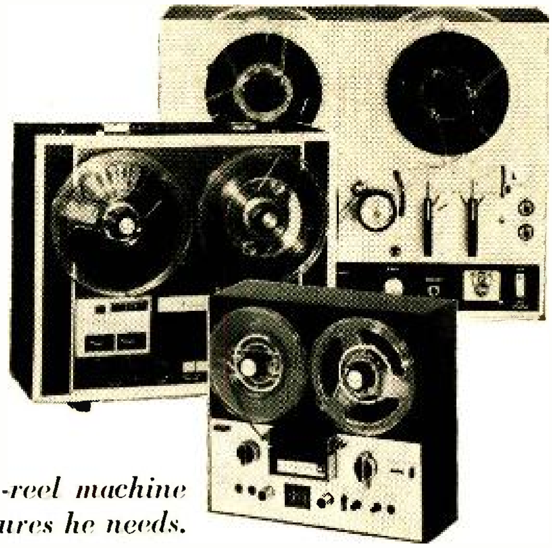


Fig. 8. This brake disable circuit is a fail-safe feature.

Fig. 9. Circuit protects against brake-circuit switch failure.



selecting a
Tape Recorder



By LEONARD P. KUBIAK / Supervisor, Tape & TV Lab.
Texas Dept. of Education

In order to get the most for his money, the buyer of a reel-to-reel machine must know the important specifications and be aware of the features he needs.

WITH the increasing popularity of audio tape recorders, a growing number of individuals will be faced with the task of selecting a recorder for his particular needs. The tape-recorder customer is often confused by the many terms and specifications used to describe tape recorders and their performance. To further complicate matters, one soon finds that recorders can cost up to several thousand dollars. In order to get the most for his money, a prospective buyer should be familiar with tape-recorder specs and select a model, within his means, that meets all of his anticipated requirements. There is nothing so disheartening as to spend several hundred dollars on a recorder only to discover that it lacks a desirable feature.

For example, the selection of a quarter-track recorder over the half-track model means a savings of 50% in tape costs. This quickly mounts up if a large library is being planned.

Professional vs Home Recorders

One of the best ways to illustrate the various features found on reel-to-reel tape recorders is by a comparison between the professional and the home recorder. Table 1 outlines the major differences between the two types.

(Editor's Note: Although this table is somewhat oversimplified, it does attempt to give general guidelines as to the differences between these two types of machine. It should also be pointed out, however, that there are many semi-professional recorders, selling for perhaps $400–$800, which combine many of the features of both categories.)

A distinctive feature of the professional tape recorder is the use of separate playback and record heads and preamplifiers (Fig. 1). Separate record and playback heads give the recording enthusiast the ability to monitor a tape during the actual recording session rather than having to wait until the recording is over to determine what, if anything, has actually been recorded on tape.

The typical home recorder, on the other hand, uses a combination record/playback head. Since the optimum head gap width for the record and playback heads are different, the combination head is, at best, a compromise between the two optimum widths. This accounts for the reduced over-all frequency response or fidelity of the home-type recorder. In addition, since the same head is used for both record and playback, it is impossible to monitor the tape during a recording session. The tape must be replayed to check the quality of the recording.

Most professional recorders are equipped with hysteresis-synchronous drive motors to maintain constant speed and a low percentage of flutter and wow. Since the hysteresis-synchronous motor is dependent on power-line *frequency* rather than voltage, it is relatively independent of amplitude variations in the a. c. power line. The hysteresis-synchronous motor turns at a constant rate of speed with an input voltage of anywhere from 105 to 125 volts a. c.

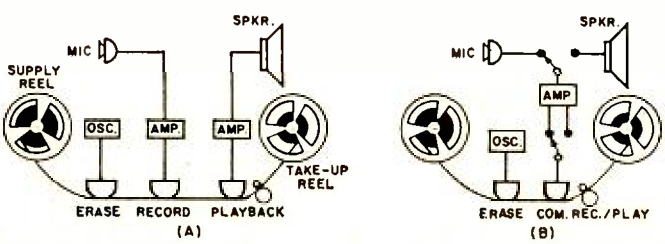
	No. of Heads	Type of Drive Motor	Over-all Freq. Response at 7½ in/s	Flutter & Wow at 7½ in/s	Timing Accuracy (all speeds)	Speeds (equalized)
Professional Recorder	3 or more, inc. sep. record & playback	Hysteresis-synchronous	20-15,000 Hz ± 2 dB	Less than 0.15%	± 0.2% or better	7½ in/s 15 in/s
Home Recorder	2—comb. record & playback	Induction	20-8000 Hz ± 2 dB	0.25% or greater	± 2.0% or greater	1⅞ in/s 3¾ in/s 7½ in/s

Table 1. Characteristics of professional and home recorders.

Home recorders, on the other hand, generally contain induction motors whose speeds vary slightly with changes in the a. c. line voltage. This factor accounts for reduced speed accuracy. This coupled with lower-quality mechanical design results in flutter and wow. (These terms are used to describe the amount of high- and low-frequency irregularity or changes which occur as the result of the variations and irregularities in tape speed.)

Approximately 0.3% flutter and wow is considered the upper tolerance limit for recording or playing classical music.

Fig. 1. (A) Use of separate playback head and electronics permits user of professional or semi-professional machines to monitor the tape while it is in process of being recorded. (B) A home-type machine uses combination record/playback head.

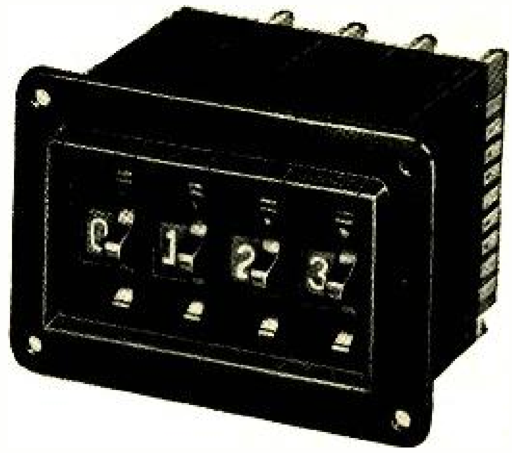


Tape Speed and Trackage

Speed accuracy is the spec which indicates how closely a tape recorder remains on standard speed (1⅞, 3¾, 7½, or 15 inches per second). For example, if a recorder is 2% fast, the pitch of a pre-recorded tape will increase noticeably. In addition, the recorder will require slightly more tape for making recordings.

In order to reproduce high-fidelity (*Continued on page* 62)

Rotary Thumbwheel Switches for Digital Applications



By JAMES R. SQUIRES

Applications and characteristics—the prices of these switches have dropped substantially due to improved manufacturing techniques.

CONVENTIONAL in-line rotary selector switches have been around the electronics industry for some eighty years. There have been some changes in these switches but none as significant as those made possible through the application of new materials and manufacturing techniques. Development was speeded in part by a growing demand by a computer-oriented industry for smaller and more reliable switches. New plastics, new methods of molding, the use of precious metals, and new printed-circuit techniques have combined to produce a new version of this component—the modern rotary thumbwheel switch (Fig. 1).

Construction of Switch

Basically, the thumbwheel switch consists of two parts. The first is the finger- or thumb-rotated shaft assembly and the second is the printed circuit. The printed circuit used in one form or another is one of the basic new differences. Another is the shaft which is mounted parallel to the front panel and drives rotating metal fingers that wipe against the printed-circuit pads. Very low torque is required to turn the switch. The wheel, molded so that little ears extend from it, can be rotated readily by the finger or thumb. Many designs provide bezels that limit finger rotation of the wheel to one position per click. Switch positions are marked on the thumbwheel itself and are visible, one position at a time, through a window.

Beryllium copper metal fingers attached to the thumbwheel are in constant physical contact with the printed circuit. The contacts wipe in a series of concentric circles over the printed-circuit configuration (Fig. 2). Output terminals at the rear of the PC board are connected to the metal fingers *via* printed wiring on one or both sides of the circuit card.

Many thumbwheel switches offer you a choice of one of three methods of connecting external circuit wiring to the switch. First, you can solder wires directly to pads or terminals on the PC board. Second, you may select a connector especially designed to mate with lugs printed onto the PC board. Wires molded into the molded thumbwheel housing comprise the third method. These wires are color-coded and connected directly to the printed board which is associated with the thumbwheel switch.

To compare a rotary thumbwheel switch with a standard

Fig. 1. Exploded schematic view of rotary thumbwheel switch.

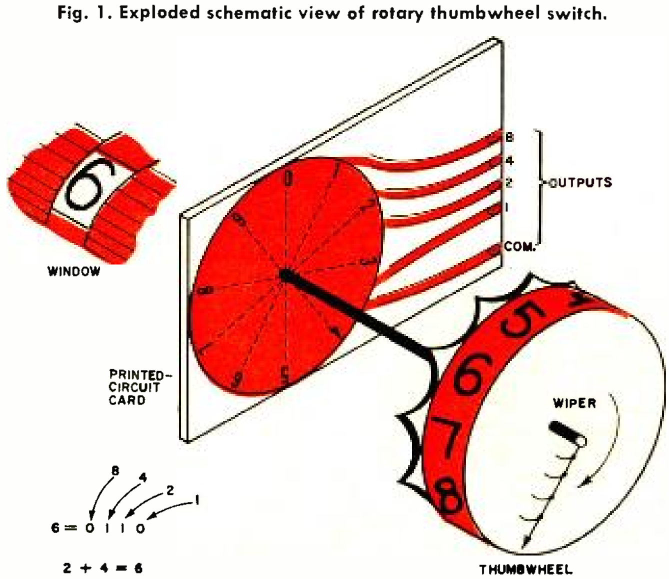
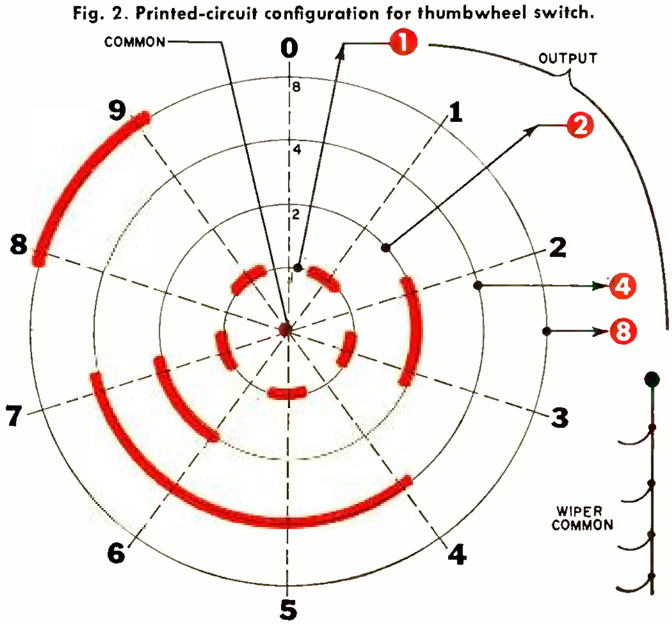
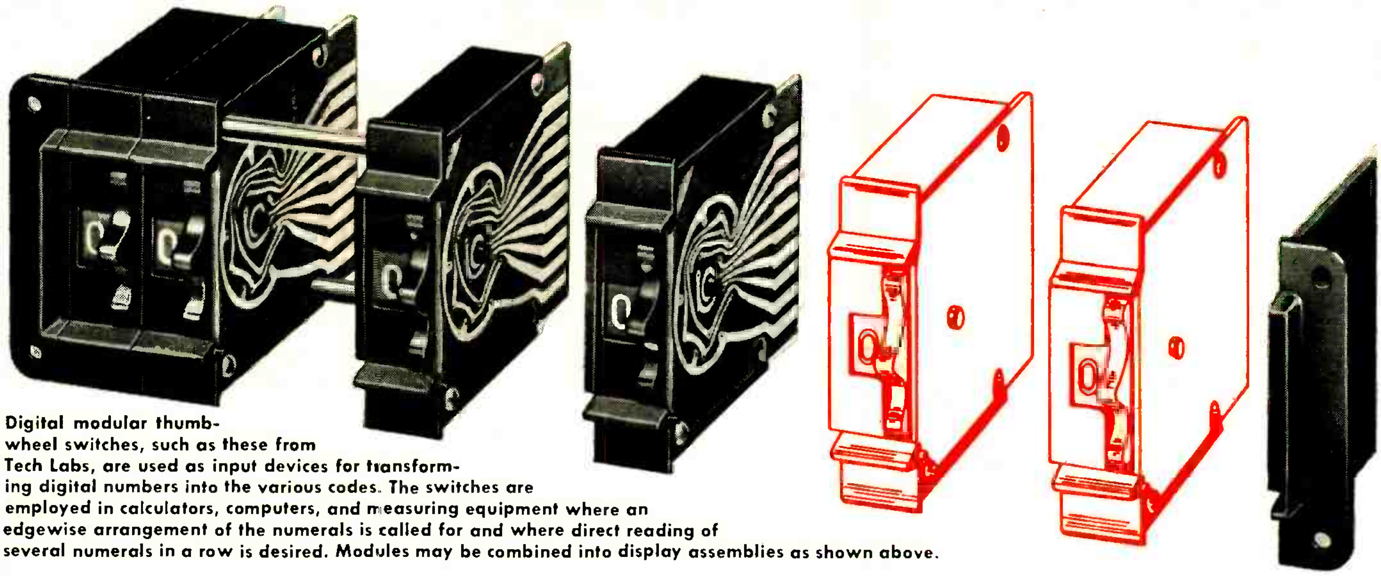


Fig. 2. Printed-circuit configuration for thumbwheel switch.





Digital modular thumbwheel switches, such as these from Tech Labs, are used as input devices for transforming digital numbers into the various codes. The switches are employed in calculators, computers, and measuring equipment where an edgewise arrangement of the numerals is called for and where direct reading of several numerals in a row is desired. Modules may be combined into display assemblies as shown above.

in-line rotary selector switch, let us wire a decimal-to-binary, 0 to 9 (10-position) switch. Assume that we want a front-panel indication of any number between 0 and 9. Also, the switch must form the binary equivalent of that panel number. Fig. 3A indicates the equivalency between binary and decimal numbers.

What About Cost?

Let us consider the cost of the switch necessary to perform this function. With an eye for minimum size, we consider a miniature phenolic in-line rotary switch with four decks and 2 to 11 positions. For this application, we can set the indexing for the 10 positions required. This switch costs us about $4. A standard off-the-shelf thumbwheel switch will cost about $5 to perform the same function. However, there is more to the comparison story than meets the pocketbook.

The cutting and soldering of the 19 or 20 wires required to assemble a switch that will provide a binary output for a decimal setting will take about 20 minutes' time and cost additionally for the wire, solder, and electricity. See Fig. 4. What is more, an additional 5 or 10 minutes would be spent in checking the wiring. All this adds up to a cost of over $6 for the conventional in-line selector switch. The thumbwheel switch, on the other hand, is prewired and tested, ready to mount and connect into the circuit.

The in-line switch requires a simple-to-cut round hole and perhaps, if desired, a smaller guide hole. To mount a thumbwheel switch, a square hole will be needed. This can be difficult to cut without the proper punches. Some of the newer thumbwheel models have flanges molded into the switch module to cover up not-quite-square openings.

The in-line switch, while easier to mount, requires more of the valuable cabinet space than the space-saving thumbwheel switch. What is more, the conventional in-line rotary selector switch must have some kind of panel markings or plates to indicate its position, while the thumbwheel switch is already marked and ready to use.

Some manufacturers of thumbwheel switches are giving you more of a bargain than you (*Continued on page 64*)

This precision voltage reference from General Resistance uses six rotary thumbwheel switches for direct digital readout as well as to provide for a dial-able voltage selection.

DECIMAL NUMBER	BINARY EQUIVALENT			
	8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1

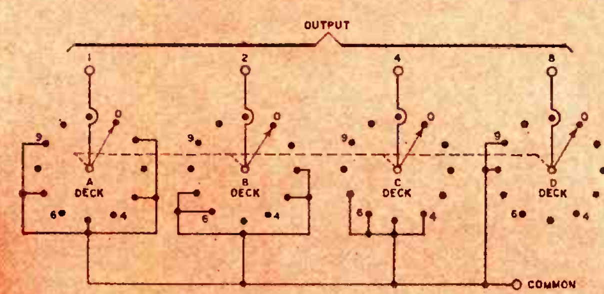
(A)

10-POSITION BCD				
DIAL	COMMON C CONN. TO TERMINALS:			
	8	4	2	1
0				
1				●
2			●	
3			●	●
4		●		
5		●		●
6		●	●	
7		●	●	●
8	●			
9	●			●

(B)

Fig. 3. (A) Decimal-to-binary conversion. (B) Dot chart.

Fig. 4. Wiring 4-deck switch for binary coded decimal.



CAPACITANCE PROBES

in Industrial Instrumentation

By RAY A. SHIVER/AiResearch Mfg. Co.

Super-precision tolerances required in making and testing today's planes and space vehicles are checked with these probes. These techniques are described.

TODAY'S aircraft and space industry requires super-precision tolerances in the manufacture and testing of components. This applies to dynamic testing and balancing, as well as precise static measurements. Dynamic measurements require that readings be taken while the test specimen is in motion, such as shaft balancing on an engine or displacement readings on a vibrating member. Static measurements involve setting precise distances between two members which are stationary at the time of installation or adjustment.

Today's instruments can accurately measure distances as small as 50 microinches. Included in this article is a description of one such system that is capable of producing excellent accuracies within the range 0.00005 to 0.5 inch.

Several methods have been employed for measuring distance (or proximity) and each will be discussed briefly.

Differential-Transformer System

The setup illustrating a variable-reluctance differential-transformer system is shown in Fig. 1A. An a.c. voltage is applied to the excitation coil as indicated. The two secondary coils, *L1* and *L2*, are connected so that they are 180° out-of-phase and no voltage is present at the output terminals. The resistive and capacitive balance is necessary to cancel out small differences in the inductance of *L1* and *L2* and to provide a means of adjusting for zero output voltage at various positions of the metallic object in relation to the differential transformer probe (core).

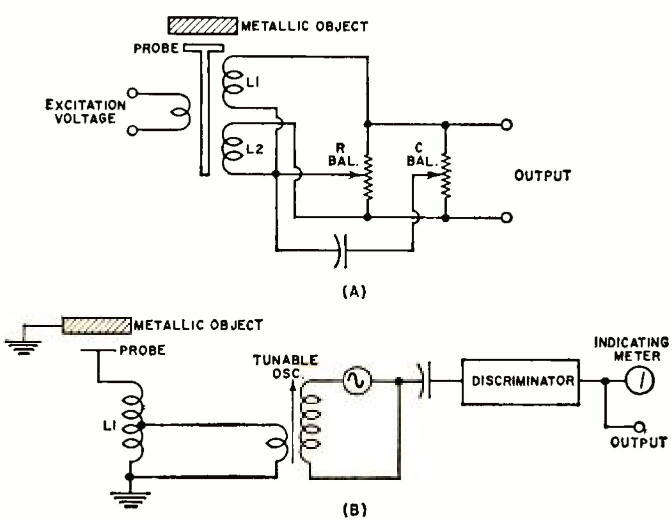
The system is first balanced with the metal object in some rest position. Any movement away from this position will change the inductance of *L1* with respect to *L2* and an unbalance voltage will be present at the output terminals which is proportional to the distance traveled. Thus, such a system is useful for measurements involving vibration and displacement.

There are two disadvantages of such a system. First, the operating range, in order to be linear, is necessarily limited to a few mils (thousandths of an inch) and, second, the accuracy suffers markedly with any change in temperature at the probe location. This shows up very noticeably as a shift in the original balance position and a loss of the zero reference point. The variable-reluctance system produces very good results over a limited operating range if the temperature at the measuring location remains constant.

FM Capacitance-Probe System

A system employing a tunable oscillator, discriminator, and tuned pickup coil is shown in Fig. 1B. The operation of such a system is as follows: With the metallic object at some rest position, the oscillator is tuned to the discriminator frequency, producing a zero output voltage. Any movement of the object away from the original position produces a capaci-

Fig. 1 (A) Differential-transformer and (B) FM capacitance-probe methods have the disadvantage of temperature problems.



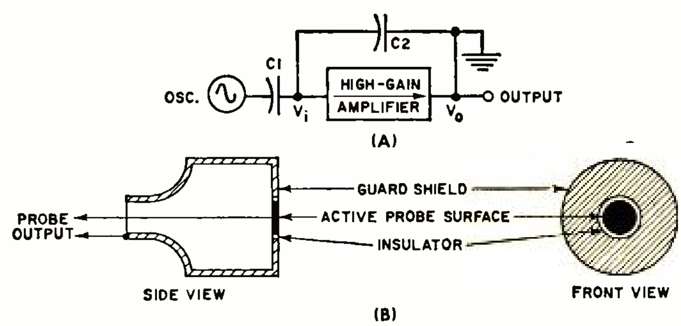
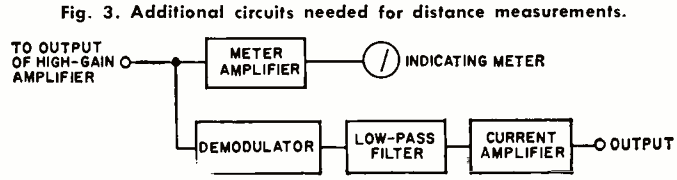


Fig. 2 (A) Feedback-loop capacitance-probe system produces output inversely proportional to C2. (B) Probe construction.

Fig. 3. Additional circuits needed for distance measurements.



tance change across $L1$, thereby causing the oscillator frequency to shift a proportional amount. The discriminator circuit in the measuring instrument produces a corresponding output voltage. Usually included with such an instrument are a meter that can be calibrated directly and an analog d.c. output voltage for use by recording devices or other measuring instruments.

This system for measuring distance is capable of good operating range and frequency response. However, it suffers one drawback that is common to the first system in that it is quite temperature sensitive.

Feedback-Loop Capacitance-Probe System

This method overcomes the temperature problem associated with the first two systems. Fig. 2A illustrates the basic circuitry for an inverse-feedback capacitance-probe system. The voltage from a high-frequency oscillator (usually 50-100 kHz) is fed to the input of a high-gain amplifier. The output voltage, V_o, is 180° out-of-phase with the input voltage, V_i, and is coupled to the amplifier input through $C2$, which completes the feedback loop. This capacitor represents the remotely located probe and test structure, with one plate the capacitance probe and the other the metallic test specimen. The amplifier output voltage is inversely proportional to the capacitance of $C2$ (capacitance between probe and test structure). Hence, a voltage, V_o, is produced whose amplitude is directly proportional to any change in distance between the probe and test structure.

Fig. 2B shows the construction of a typical capacitance probe used with a feedback-loop measuring system. The cross-section shows the button (active probe surface), insulator, guard shield, and body of the probe. The center button is connected through a shielded cable to the high side of the amplifier input. The guard shield effectively eliminates any stray capacitance pickup at the sides of the probe and confines the active surface to the front of the center button. The test structure and one side of the amplifier output are connected to ground through a separate ground-return line.

Distance & Vibration Measurements

The additional electronics needed to condition the amplifier output signal for distance measurement is shown in the block diagram of Fig. 3. This consists of a meter amplifier and indicating meter, a demodulator, low-pass filter, and a current amplifier. The latter is used to provide a d.c. analog voltage, at low source impedance, for recording instruments.

As the distance between the capacitance probe and the metallic surface decreases, the output voltage at the standard oscillator frequency increases correspondingly. If the test structure is undergoing motion, such as a rotating cam or shaft, the standard signal will be amplitude-modulated by this action. The signal is then demodulated, fed through the low-pass filter, and appears at the output of the current amplifier. The low-pass filter removes any vestiges of the oscillator standard frequency. The resulting output signal may be displayed on an oscilloscope or recorded on a suitable instrument.

Vibration is measured by the capacitance-probe system, as shown in Fig. 4. The vibrating member (M) begins at a rest point and oscillates through a total distance (D), producing a peak-to-peak sinusoidal wave as shown in the diagram. The signal is then fed to the demodulator as indicated. A rectified signal whose amplitude is directly proportional to the displacement we wish to measure ($D2$) is produced at the demodulator output.

The signal is then amplified by the current amplifier where it may be displayed on an oscilloscope or used to drive suitable recording devices. If an indicating meter is used, a suitable peak-detecting circuit is employed. The damping characteristics are such that the meter indicates true displacement ($D2$) between the capacitance probe and the vibrating member.

It is often desirable to express vibration in terms of acceleration (G forces). This is especially true when the frequency of the vibrating structure encompasses a moderately wide range.

A setup that will readily determine the G forces present makes use of a scope and a digital frequency counter. The signal from the distance meter is connected to the X-axis of the scope. A variable-frequency oscillator covering the appropriate range to be measured is connected to the Y-axis. The frequency counter monitors the oscillator output. In order to determine the frequency of the vibrating structure, the oscillator frequency is varied until a stationary circular Lissajous pattern is produced on the screen. At this point, the oscillator frequency equals that of the vibrating structure and may be conveniently read on the digital frequency meter. With the frequency and displacement of the vibrating structure known, the G forces may be calculated using the formula: $G = 0.0511Df^2$ where G = units of gravity (386 in/s^2), D = displacement (p-p amplitude in inches), and f = vibration frequency in hertz.

As a practical matter, hand calculators are available to derive this data, which eliminates the need for pencil and paper computations.

Typical Instrumentation Setup

Fig. 5 is a typical setup for both static and dynamic measurements, using capacitance probes. The cutaway drawing shows two capacitance probes mounted in such a manner as to read vibration, displacement, and thermal stress on a gas turbine engine. Probe $P1$ is mounted on a stationary member independent of the engine. Probe $P2$ is mounted on the engine shroud itself in such a manner that it sees the tips of the blades on the turbine wheel.

In order to insure accurate data from the measuring probes it is necessary to provide an (*Continued on page* 81)

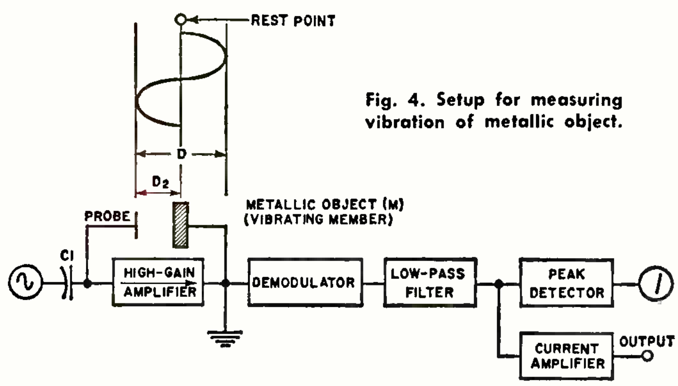


Fig. 4. Setup for measuring vibration of metallic object.

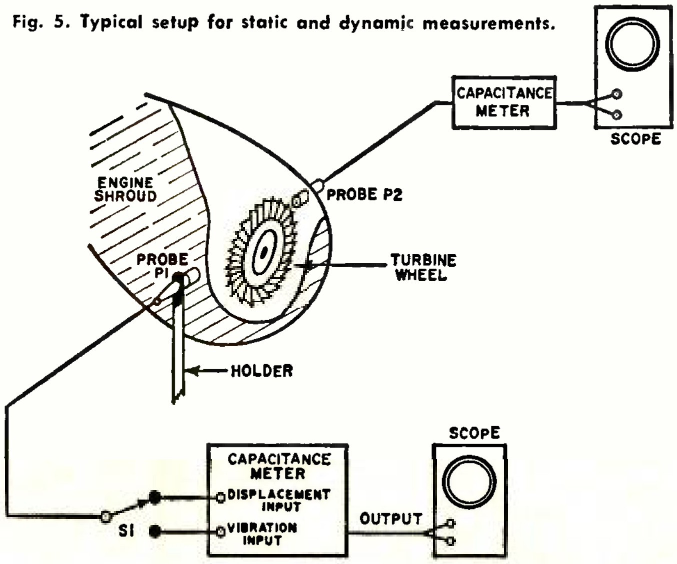


Fig. 5. Typical setup for static and dynamic measurements.

ELECTROHYDRAULIC EFFECT

By L. GEORGE LAWRENCE

Intense mechanical shock waves that are produced by underwater discharges of stored electrical energy, may be used to work metals, split rock, or propel marine vehicles.

WHEN stored electrical energy is suddenly released by high-speed electronic switches and electrodes immersed in water, an intense mechanical shock wave is created. The wave is characterized by a steep leading edge and a minor bubble pulse trailing at the end. Termed *electrohydraulic effect,* it's an easy way to convert electrical energy into a moving force. It can be used to press hard-to-handle metals like titanium and niobium into dies, spall cathode plates, split hard rock, and propel marine vehicles. The number of possible uses is restricted only by the imagination of the practical engineer.

Principles of Operation

Electrohydraulics apparently originated as a technical parlor demonstration. Decades before the turn of the century, educated experimenters contrived various types of so-called "electric pistols" and "Leyden artillery." These potentially very dangerous devices consisted of little more than an elongated cylinder containing two insulated spark-gap electrodes and some water. A lightweight stopper or projectile sealed it off. Then, by discharging a battery of Leyden jars through the electrodes, both water and stopper would blast free.

This seemingly primitive principle contains the basic components of modern energy-discharge systems: (1) d.c. energy-storage capacitor, (2) discharge electrodes, (3) force-transfer liquid, and (4) a tank. The technique, taken together, was refined by the Russian scientist L. A. Yutkin and demonstrated, in 1938, as an industrial tool for metal forming.

A basic electrohydraulic system is shown in Fig. 1. The necessary high voltage, about 20 kV, is obtained from a line-operated d.c. power supply and charges a capacitor storage bank rated from 1 to 15 microfarads. Safety devices "bleed" the circuit *via* high-resistance discharge paths. When the electronic trigger circuit is activated, energy is rapidly dumped into concentric or opposing spark-gap electrodes submerged in the water-filled tank. The resulting shock wave is directed at the work piece, as shown in Fig. 2. In this example a metal sheet (at the left) is being forced into a prepared forming die.

Although the outward appearance of the electrohydraulic effect is that of a simple chemical explosion (*i.e.*, flash of light, noise, hefty splash of water), its constituents are much more complex.

Unlike a chemical explosion whose dynamics are measured in terms of milliseconds, the electrohydraulic event takes place in microseconds. The sudden release of stored energy results in the generation of a small vapor bubble which, for all practical purposes, acquires the characteristics of a plasma. Its temperature can be as high as 30,000° C, accompanied by pressures estimated to peak out at approximately 20,000 atmospheres. Active chemical species generated by the short-term plasma include hydroxyl (*HO*) radicals, ozone, hydrogen, and oxygen. This attendant electrochemistry is recognized as an effective method for destroying harmful micro-organisms in water and it might, in time, lead to the development of economical methods for treating polluted rivers and streams.

An electrohydraulic discharge unit suitable for laboratory applications is shown in Fig. 3. The safety spark gap, C_s, protects the main storage capacitor (C_e) from rupture caused by overvoltage.

The energy stored in capacitor C_e is calculated as: $W = ½(QE) = ½(CE^2) = Q^2/2C$ where W = energy, expressed in joules (or watt-seconds); Q = charge in coulombs; C = capacitance in farads; and E = applied voltage.

Using this equation, it can be shown that the efficiency for converting electrical input power to the electrohydraulic assembly is about 50 percent, that is, 2 kWh of power will provide 1 kWh or 3.6×10^6 joules of effective energy.

This energy can be fed to a variety of high-speed release devices, such as the ignitron or triggered spark-gap, to provide a rapid dumping cycle.

The spark-gap switch, as shown in Fig. 3, is triggered by a high-voltage pulse to start conduction. The pulse is supplied by transformer T_t which, in turn, has its primary pulsed by energy stored in capacitor C_t and released by the firing of the SCR.

If switch S1 is opened, the entire system can be triggered manually by a push-button. If S1 is closed, the UJT and its timing network are connected to the gate of the SCR and automatic pulsing is possible.

However, automatic pulsing—which requires an exact determination of power-supply capabilities—is not too common in simple electrohydraulic applications. The flasher can be used to trigger the UJT. This provides additional assurance

Table 1. Constituents of prepared "Sea-Rite" electrolyte.

Sodium	30.577 %	Chloride	55.035 %
Magnesium	3.725 %	Sulphate	7.692 %
Calcium	1.178 %	Bromide	.1868%
Potassium	1.099 %	Bicarbonate	.405 %
Strontium	.0382%	Fluoride	.0039%
Boron	.0135%		

Mixture of 35 grams to be dissolved in 1 liter of clean tap water.

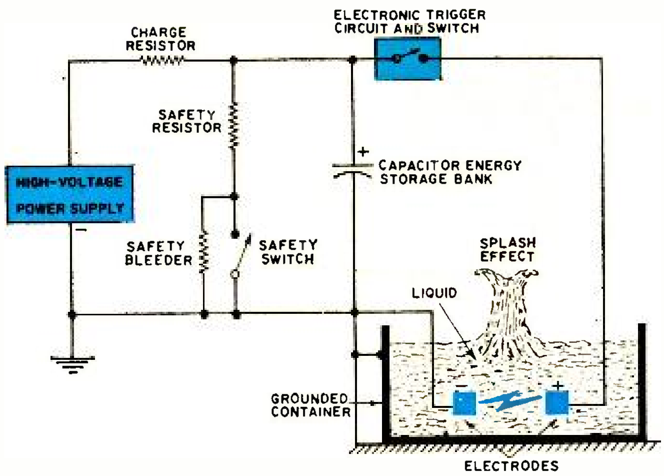


Fig. 1. Electrohydraulic system has power supply, trigger, storage capacitor, and submerged electrodes in circuit.

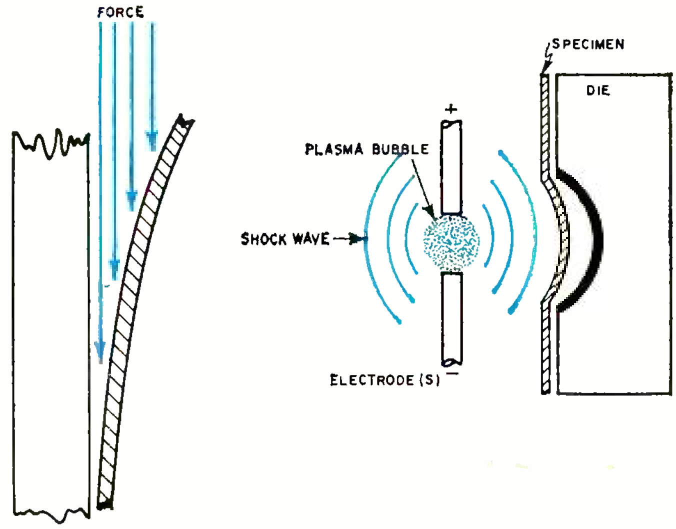


Fig. 2. Shock wave used for shearing (left), metal forming (right).

that the energy-storage capacitor C_e has been charged to its maximum design potential. The method, as drawn, depicts a non-synchronized, free-running triggering mode. The UJT trigger circuit and C_e's charging rate must be synchronized for marine and related applications.

Marine Electrohydraulics

Spark-type electrohydraulic systems have been used with great success in sea-bottom profiling. Typically, sparkers in a floating container are towed behind a research vessel. With input voltages of about 12 kV, the electric spark gives out a broad-frequency sound pulse. This noise, which sounds similar to the detonation of a small blasting cap, is directed toward the sea bottom. Hydrophones pick up the return echo and feed electrical signals to a graphic recorder. The method is similar to sonar, but considerably less complex and expensive.

The use of electrohydraulics for marine propulsion purposes is, at this time, entirely experimental. Although a very noisy method of propulsion, its main advantages are that rotating propellers and drive trains are not needed to move a ship.

However, underwater electrohydraulics are being used as "sounding" marker buoys. Sea-water batteries, samples of which are described in U.S. Patents 3,036,141 and 3,036,142, are used as system energizers. A typical sea-water battery may consist of 12 paralleled magnesium plates and 13 steel plates with a flash nickel plating, also connected in parallel. A battery having a total effective area of 8.7 square feet has an output power curve like that shown in Fig. 4B. The data was obtained with simulated sea water (see Table 1). Sold under the tradename "Sea-Rite," chemicals for making this water may be obtained from *Lake Products Co.*, St. Louis, Missouri.

Since the sea-water battery's output voltage is very low (about 0.25 volt at 10 amperes, or 2.5 W), a tunnel-diode type converter is employed to generate the potential necessary for the electrohydraulic effect. An intermediate acoustical chamber, filled with distilled water and coupled to the surrounding sea by means of a diaphragm, may be used to reduce corrosion and other damaging effects, including system electrolysis.

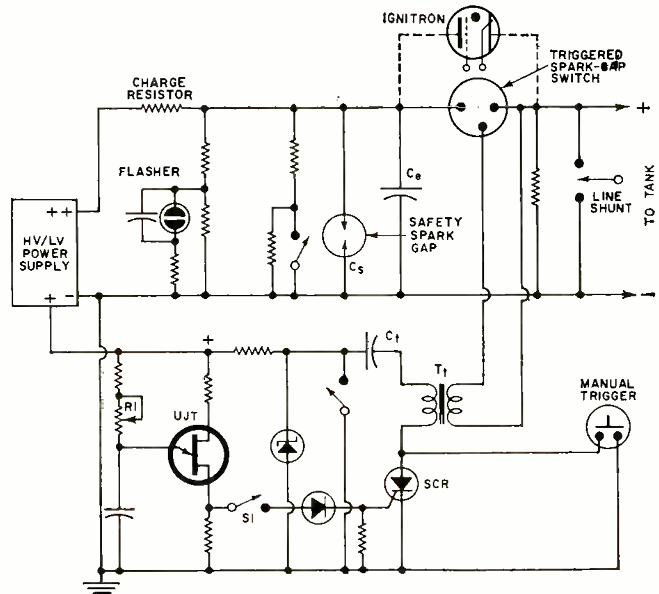


Fig. 3. Power unit schematic diagram. Either a triggered spark gap or ignitron can be used to discharge capacitor C_e into an external work circuit. See text for the details.

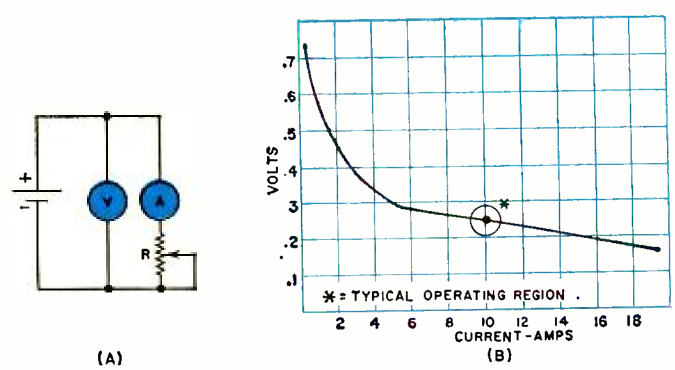


Fig. 4. (A) Load-test circuit used to develop sea-water load curve. (B) Typical operating point is at 0.25 volt/10 amperes.

Squib Systems

Exploding bridge wires, connected to electrodes of a high-voltage discharge system, are technically known as "squibs." The device is popular in rocketry and certain areas of electrohydraulics. Squibs permit the use of low system voltages, typically below 5 kV. Using thin wire of 1 ohm per millimeter and not longer than 3 mm, an acceptable vapor envelope can be generated by discharging an 80 μF, 150 V d.c. capacitor through it.

Because of their mechanical makeup, squibs necessarily limit the repetition rate of an electrohydraulic system. Self-arming spark gaps can be constructed by feeding exploding bridge wire (EBW) through and between insulated forks. However, the process consumes time and requires the use of threading mechanisms. But the technique is useful when working in liquid insulators such as oil.

Squibs and related EBW systems (*Continued on page* 86)

ATOMIC RADIATION: TYPES & RELATIONSHIPS

By JOSEPH H. WUJEK, Jr.

Part 1. Not knowing what radiation is all about is as dangerous as the phenomenon itself. This article explains some fundamental concepts.

Editor's Note: This is the first of a three-part series of articles which attempts to disperse the fog of misunderstanding surrounding radioactivity. Part 2, scheduled to appear in the June issue, will cover radiation detection processes, while Part 3, which will appear in the July issue, covers radiation measurements.

THE public understands little of atomic energy; and, in general, neither does the technical community (except, of course, those actively engaged in atomic physics work). The purpose of this article is to briefly discuss some of the common types of atomic radiation and, hopefully, remove some of the mystery which surrounds them.

However, before exploring the radiation process, it would be helpful if we first discussed the makeup of an atom.

The Building Blocks of Atoms

Fig. 1 is a simple conceptual model of a helium atom. The nucleus, which is composed of neutrons and protons each having a mass approximately 1.7×10^{-27} kilogram, is in the center and the electrons revolve in orbital shells about it. An electron has a mass of about 9.1×10^{-31} kilogram, or about 1/1900th that of a proton or neutron. (One kg equals 2.2 pounds in a 1-g gravitational field.)

The neutron, as the name suggests, is electrically neutral. But the electron carries a negative charge of 1.6×10^{-19} coulomb; the proton has the same charge but it is of opposite polarity. An atom which is not *ionized* has an equal number of electrons and protons, and thus a net charge of zero, the "+" nuclear charge neutralizing the "−" electron charge.

The number of protons in the nucleus determines the *element*. There are over 100 elements known to scientists, some of which are extremely rare. The sum of the protons and neutrons in the nucleus determines the atomic *mass* of the element. Atoms of the same element having different masses are called *isotopes*. The most abundant isotope of oxygen, for example, has eight protons and eight neutrons—a mass of 16. But isotopes having masses of 17 (8 protons, 9 neutrons) and 18 (8 protons, 10 neutrons) exist. Except for properties due to the mass difference, these oxygen atoms behave (chemically) in identical fashion. Incidentally, many isotopes are unstable, decaying and disintegrating spontaneously. More than 1300 natural and artificial radioisotopes have been identified.

When the chemical symbol for an element is written, a subscript is used for the number of protons (the "+" charge on the nucleus, also called atomic number Z) and a superscript for the nuclear mass (sum of protons and neutrons). Thus an oxygen atom of 8 protons and 9 neutrons is written: "$_8O^{17}$," the "O" being the chemical symbol for oxygen. Symbols for elements can be found in physics and chemistry texts and other scientific handbooks.

Particle Energy

The standard unit of energy used in atomic physics is the *electron-volt*, abbreviated eV. The familiar prefixes "k" for thousand and "M" for million are also used, as keV and MeV. One electron-volt is the energy imparted to an electron when accelerated through a potential of one volt. For energies W, below about 10 keV, the relation $W = \frac{1}{2}M_0v^2 = eV$ is sufficiently accurate, where M_0 is the "rest mass" of the particle (kilograms), v is the velocity (meters/second), e is the electron charge (1.6×10^{-19} coulomb), and V is the potential difference in volts. For particles of higher energy, the Einstein relation must be used:

$$W = \frac{M_0c^2}{\sqrt{1 - (v/c)^2}}$$

where $c = 3 \times 10^8$ meters per second, or the velocity of light in vacuum. Therefore, we see that we cannot accelerate a particle to the speed of light for, if we try, $v = c$, and the denominator goes to zero, yielding an undefined value of W.

One other equation is useful, the expression $W = h\nu$. Here, h is Planck's constant, or 6.62×10^{-34} joule-second. The Greek letter ν is the frequency of a wave. The French physicist, de Broglie, detailed the relationship between particles and waves but, for our purposes, it is sufficient to recognize that $\nu = c/\lambda$, where λ is the wavelength of the radiation. Thus, for an x-ray of $\lambda = 1.24 \times 10^{-12}$ meter $\nu = 3 \times 10^8$ meters per sec/1.24×10^{-12} meter or 2.42×10^{20} hertz. Then the energy is simply $W = h\nu = 6.62 \times 10^{-34}$ joule-second $\times 2.42 \times 10^{20}$ per second $= 1.6 \times 10^{-13}$ joule, or in electron-volts (dividing by the electron charge) 10^6 eV, or MeV. It is useful to recognize that a volt is equivalent to one joule per coulomb.

Having thus prepared ourselves with a few simple relationships, we next examine the principal kinds of atomic radiation encountered in the laboratory and in nature.

Atomic Radiation

The four levels of atomic radiation which we will discuss are: *alpha* (α) particles, *beta* (β) particles, neutrons, and *gamma* (γ) and x-rays. We consider γ and x-rays as one level of radiation since they are both, essentially, high-energy rays.

The least damaging (from a biological standpoint) and the easiest to shield are α particles. Alpha particles are helium ions which have lost two electrons and thus have a charge of $+(2 \times 1.6 \times 10^{-19})$ coulomb. A moderate energy α beam may be attenuated by placing a barrier, such as aluminum foil, in the path of the particles. Paper and cloth also provide shielding from α radiation.

Free electrons, or β rays, are more difficult to shield than α particles. They interact with the bound electrons of atoms and produce x-rays, thus creating a secondary source of radiation.

Neutron radiation, in general, requires a thicker shield than either α or β radiation. Because of the relatively high mass and volume of neutrons, interactions occur when these particles bombard matter. Materials which provide good shielding against neutron radiation are termed moderators. Moderator material in the form of rods is commonly used to control neutron flux levels in reactors. By inserting or removing control rods from a reactor core, more or fewer neutrons are permitted to interact and the reactor heat (power level) is regulated.

Gamma radiation and x-rays require the heaviest shielding. Lead is the most common material used for this application. It is convenient to think of γ and x-rays as electromagnetic energy of very short wavelength. However, all radiation (and all matter) exhibits the dual properties of particle and wave phenomena, but α, β and neutrons are considered particles, while γ and x-rays are thought of as waves. These "visualizations" are useful models, but we should not forget that they are both particle and wave.

Radiation can be generated in various ways. Some elements have isotopes which are naturally radioactive and emit radiation, while other elements have radioactive isotopes which are artificially created, or both kinds may exist. Artificial radio-isotopes are produced by the high energy bombardment of elements by particles. Usually particle accelerators are used to provide scientists with artificial isotopes.

The half-life of an isotope refers to the time required for one-half of the radioactive material to change into another elemental form. Half-lives vary with the particular isotope, and may be as short as picoseconds (10^{-12} second) or as long as 10^{12} years and more. As an example of radioactive decay consider the reaction ${}_{92}U^{238} \rightarrow {}_{90}Th^{234} + \alpha + \gamma$. This reaction is read, "Uranium 238 (Z of 92) decays to Thorium 234 (Z of 90), yielding an α particle $({}_{2}He^{4})^{++}$ and γ-ray energy." Notice that the subscripts and superscripts balance, since the α particle is a helium (*He*) ion. The half-life of this reaction is 4.5×10^{9} years, meaning that if we start today with a specific quantity of ${}_{92}U^{238}$, in 4.5×10^{9} years half of the U^{238} would still be reacting, while the other half would have degenerated into the stable atom Th^{234}. We have omitted the subscripts in the last writing since the meaning is clear. It is this kind of measurement of carbon-14 content that allows geologists to estimate ages of rocks.

Biological Hazards

Even the briefest of discussions of nuclear radiation must point out the safety hazards associated with these emanations. Since the human body is a complex of chemical compounds, atomic radiation interacts with body molecules to produce chemical changes. Some of these changes may be beneficial, as in the case of radiological treatment of cancerous tissue. But, in general, excessive radiation causes detrimental effects in body chemistry. Often permanent changes in cell structure result, causing, among other things, mutations in the offspring of the victim. Such mutations may take several generations to become evident.

Other serious interactions can occur in blood cells, leading to a condition not unlike leukemia in symptoms. And while radiation can be used to treat cancer, radiation can also produce cancerous growths. Damage to the body organs is another biological hazard which must be avoided. Tests conducted over long periods of time have led to safety standards for radiation dosage, which we will examine after we define some of the units used in this work.

Radiation Units

The principal units used in biological radiation work are: the roentgen, the rep, the rad, and the rem.

The roentgen, named after the German physicist who at the end of the 19th century discovered x-rays, is the quantity of x or *gamma* radiation which will generate 2.08×10^{9} ion-pairs in one cubic centimeter of air, measured at standard conditions (approximately 14.7 lbs per square inch of atmospheric pressure and a temperature of 32°F). Ion-pairs refers to the stripping of electrons from atoms by incident radiation energy, giving rise to one ion and one electron. The roentgen (abbreviated R) does not take into account exposure time. Time is important because the longer the exposure the more damaging the radiation burn. Thus, the roentgen as a measurement unit has limited use in biological radiation work.

The rep, or roentgen equivalent physical, relates radiation to ionization in tissue and yields a measurement which is more meaningful in human exposure. The rep is approximately equivalent to 1.1 times the energy intake of tissue as compared to air. Hence, if in a given radiation flux, the air absorbs x energy units, tissue will absorb x times 1.1 energy units. But, again, time is not included.

The rad, or radiation absorbed dose, is a measure of energy absorption in any material and is equivalent to approximately 1.2 times the energy intake of the medium as compared to air.

The rem, or roentgen equivalent man, is the quantity of any type of radiation which will produce the same biological action in man as the absorption of 1 roentgen of x-irradiation. The rem may be calculated by multiplying the roentgen level by certain constants which depend upon the type of radiation involved. These factors, called the relative biological effectiveness (RBE) factor, vary from one to 20 or more. Thus 1 roentgen of x-ray or *gamma* radiation has an RBE of 1, while a 5 MeV neutron has an RBE of 10. So 1 R of x-ray radiation is equivalent of 1 rem, while 1 R of the 5 MeV neutron radiation is $1 \times 10 = 10$ rem.

Since safety levels or radiation depend upon time exposure as well as the area of the body exposed, there is some variation in the level of absorbed radiation permitted. For safety sake, those who work in radiation areas should be cognizant of the Atomic Energy Commission's Standards for radiation protection.

(Continued Next Month)

MAKING AN ISOTOPE

Several processes are used to create radioactive isotopes. The most common is the (n, γ) process where a neutron is captured by a target atom and a gamma photon emitted immediately. Since there is no change in the atomic number, the resultant element remains the same as the target material. In the (n, p) process, the neutron entering the target material has sufficient energy to cause a proton to be released. Therefore, the atomic number is changed by 1 and the affected atom transmuted into a different element. On the other hand, the capture of a high-energy neutron in the (η, α) process causes an alpha particle to be emitted and the atomic number reduced by 2. In the fission process, several isotopes of an element can be produced. Typically, these are fragments of uranium atoms which have undergone fission (radioactive atoms from atomic numbers 30 through 64).—Editor

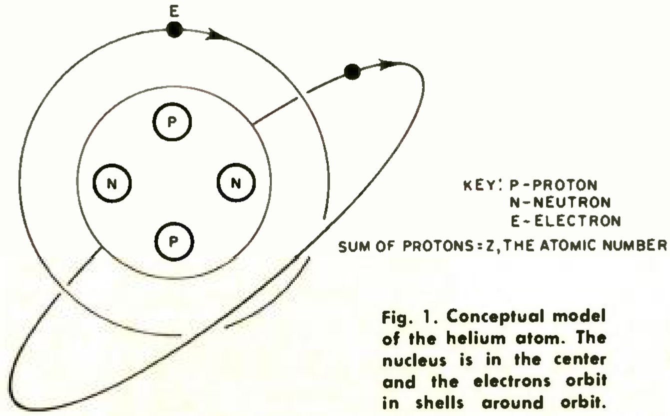
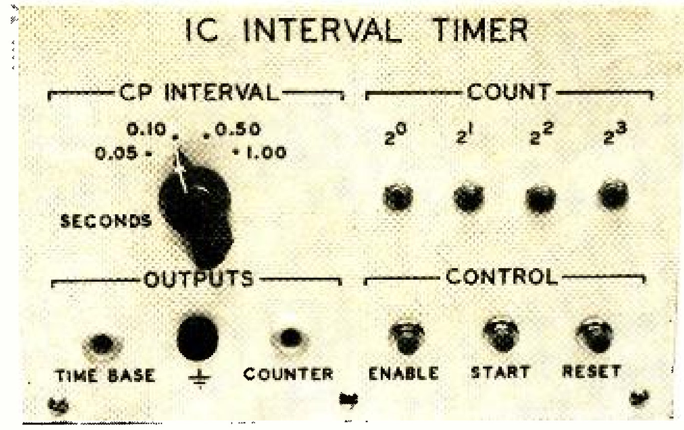


Fig. 1. Conceptual model of the helium atom. The nucleus is in the center and the electrons orbit in shells around orbit.

a digital IC timer



By DONALD L. STEINBACH / Research Engineer, Lockheed Missiles and Space Co.

Digital electronic timers exhibit excellent resettability and repeatability. IC's and a 60-Hz line-frequency time base provide a high performance/cost ratio.

ONE-hundredth of a second may be the winning margin in an athletic event or it may be the decision time which sends an Apollo spacecraft winging its way to the moon. Whatever the importance of the moment, digital interval timers have become the most effective method of controlling timed events. Here is a timer designed for applications where repeatability and high accuracy are of prime importance.

In "popular" electronics—that nebulous area inhabited by hobbyists, experimenters, and part-time enthusiasts—cost is important. Since this timer does its job using very low-circuits, it should be of interest to beginners and professional electronics people alike.

The timer provides four timing ranges, each divided into 15 discrete steps: 0.05 second to 0.75 second in increments of 0.05 second; 0.10 second to 1.50 seconds in 0.10-second increments; 0.50 second to 7.50 seconds in 0.50-second intervals; and 1.00 second to 15.0 seconds in 1.00-second increments. In all of the timing circuits, low-cost integrated circuits are employed.

Fig. 1 is a block diagram of the timer. The time-base generator provides the accurately spaced clock pulses which the counter counts when it is enabled by the Control section. The Decoding and Gating section monitors the counter's state and provides outputs according to the settings of the Count switches. The Control section processes inputs from the Control switches and from the Decoding and Gating section to start, stop, and reset the counter.

Integrated circuits—*Fairchild Semiconductor's* RTμL 9923 JK flip-flops and RTμL 9914 dual two-input gates—are used throughout. If discrete components were used, 211 transistors and 271 resistors would have been needed to construct the unit.

For information purposes, an outline drawing of each IC is shown in Fig. 2. Each dual two-input gate contains two two-input (two input terminals and one output terminal) *nand/nor* gates. If both gate inputs are "0", the gate output is "1". If either input (or both inputs) is "1", the output is "0".

The JK FF has four inputs (S,T,C, and P) and two outputs (Q and $\overline{Q}$). In one of its two stable states, the "0" state, output Q is "0" and output $\overline{Q}$ is "1". In the "1" state, output Q is "1" and output $\overline{Q}$ is "0". The FF remains in either of these two states until the signals at S, T,C, or P cause it to switch.

For example, if a "1"-level (high-level) signal is applied to input P, the FF will switch to the "0" state and cannot change until the signal is removed from P. A "0"-level (low-level) signal applied to P has no effect on the state of the FF. Actually input P functions independently of inputs S, T, and C. T is the toggle signal input, and S and C are control inputs.

If S and C are both "0" prior to the arrival of clock pulse at T, the FF changes state with each successive pulse. If S and C are both "1", the FF does not change state. If S is "1" and C is "0", the JK either switches to the "1" state or remains in the "1" state; and if S is "0" and C is "1", the FF either switches to the "0" state or remains in the "0" state.

Time-Base Generator

The time-base generator (Fig. 3) consists of seven JK flip-flops and one dual two-input gate package. Incoming 60-Hz clock pulses are fed to *FF*1 and *FF*2 which divide the 60-Hz input by 3. The resulting 20-Hz signal provides clock pulses at 0.05-second intervals ($T = 1/f$). *FF*3 divides the 20-Hz signal by 2 to provide clock pulses at 0.10-second intervals, and *FF*4, *FF*5, and *FF*6 are connected in a divide-by-five circuit configuration to obtain the 0.50-second timing interval. The 2-Hz output of *FF*6 is divided by *FF*7 for the 1.0-second clock pulse. Notice one-half of the dual two-input gate is used as an inverting amplifier to boost the divide-by-five input signal level and the other half to amplify the final clock-pulse output.

Counter

The counter, Fig. 4, consists of four JK FF's connected in a binary count-down arrangement. Clock pulses from the time-base generator are continuously applied to the input of the counter (T of *FF*1). As long as inputs S and C (*FF*1) are at the "1" level, *FF*1 cannot toggle and none of the FF's in the counter responds to the pulses. When S and C drop to the "0" level, counting action begins. The first clock pulse switches *FF*1 to the "1" state and Q (*FF*1) changes from "0" to "1" and $\overline{Q}$ from "1" to "0". This "1-to-0" transition at $\overline{Q}$ is recognized as a clock pulse by *FF*2 and it, too, switches to the "1" state. In like manner, *FF*2 switches *FF*3 and *FF*3 switches *FF*4 to the "1" state.

The second clock pulse switches *FF*1 back to the "0" state, but the "0-to-1" transition of $\overline{Q}$ of *FF*1 is ignored by *FF*2, therefore, *FF*2, *FF*3, and *FF*4 do not change state. The third CP switches *FF*1 back to the "1" state. Now *FF*2 switches, but *FF*3 and *FF*4 do not. This process continues until finally, at the 16th pulse, all four FF's are in the "0" state.

The waveforms at the outputs of each FF are shown in

Fig. 5. The input signal is a square wave and its "1-to-0" transitions represent CP's to *FF*1. The "1-to-0" transitions of *FF*1 Q are CP's to *FF*2, etc. Notice that there are 16 possible combinations of FF outputs. Thus, the number of pulses received at *FF*1 can be determined directly from the states of the counter's four FF's. Since the time interval between the pulses is known, the timing interval (the elapsed time during which the counter output terminal is at the "1" level) is directly proportional to the number of CP's received by the counter.

Decoding and Gating

Gates 1, 2, and half of gate 3 comprise the Decoding and Gating section. Its primary function is to provide a "1"-level signal at the Counter Output terminal during the timing interval and a "0"-level signal at all other times. Its secondary function is to provide a signal for the Control section.

The length of the timing interval is determined by the positions of the Count switches and the position of the Clock Pulse Interval switch (see Fig. 3). The length of the timing interval is the product of the time between clock pulses and the sum of the Count switch positions. In Fig. 4, all four of the Count switches are in the "up" position, therefore the sum of the switch positions is $2^0 + 2^1 + 2^2 + 2^3 = 1 + 2 + 4 + 8 = 15$. If the Clock Pulse Interval switch is in the 1.00-second position, the time interval would be 15 seconds long. If only the 2^1 (*S*2) and 2^2 (*S*3) switches were in

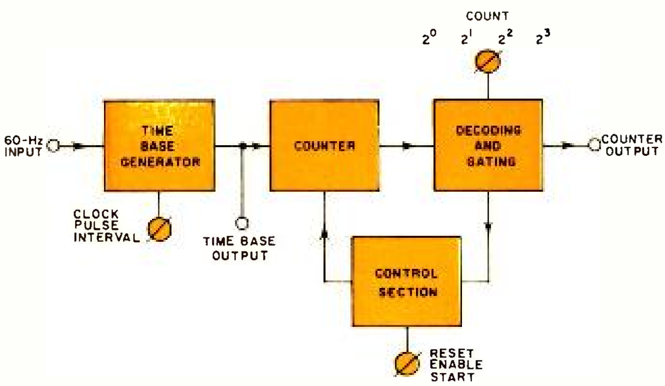


Fig. 1. A block diagram of the digital timer. The 60-Hz input must be a fast-fall-time pulse.

the "up" position, then the time interval would be $1(2^1 + 2^2) = 1\ (2 + 4) = 6$ seconds.

The function of *G*1 is to determine when the counter leaves the reset state (where all Q's are "0") and to identify the *beginning* of the timing interval. *G*2 generates a signal to identify the *end* of the timing interval. The Counter Output from *G*3 is "1" if, and only if, both of its inputs (from *G*1 and *G*2) are "0". The counter's output is "0" if at least one of its inputs is "1".

Prior to the start of the timing cycle, the counter is reset, that is, Q of each FF is "0." Thus, all inputs to *G*1 are "0" and its output is "1". The "1" output holds the counter's output at "0", regardless of the level of the output from *G*2. *G*2's output will be "1" for the switch positions shown in Fig. 4 (count of 15), and "0" for any other combination of Count switch positions. The timing cycle starts with the first CP that occurs after S and C of *FF*1 are switched (by the Control section) to the "0" level. At that instant, all four inputs to *G*1 step to "1" and the output of *G*1 steps from "1-to-0". Since one or more of its inputs is always "1", *G*1's output remains at "0" until the counter is reset (or reaches a count of 15). In like fashion, the timing cycle begins and the output of *G*2 steps to "0" (or remains at "0"). With both inputs at *G*3 "0", the counter's output steps to "1" and remains at this level until the end of the timing cycle.

As the counter counts, its FF's continue to change state until the particular signals selected by the Count switches

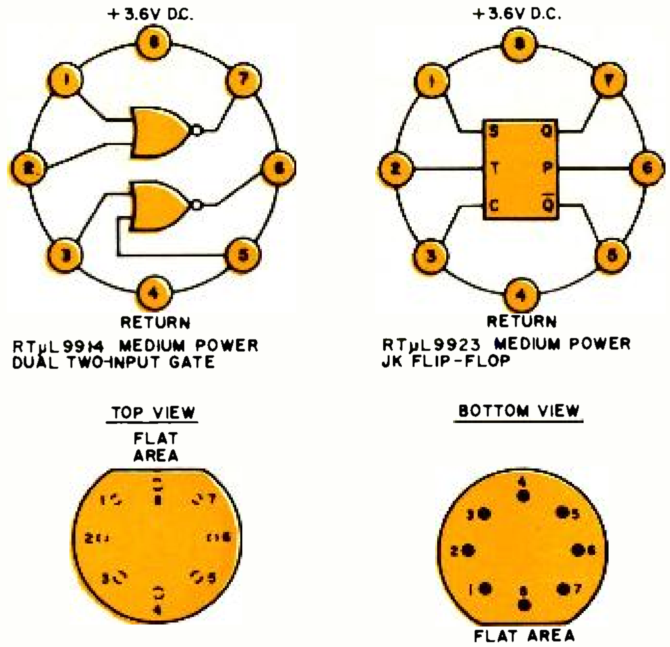


Fig. 2. Outline drawings of the IC gate and the JK flip-flop.

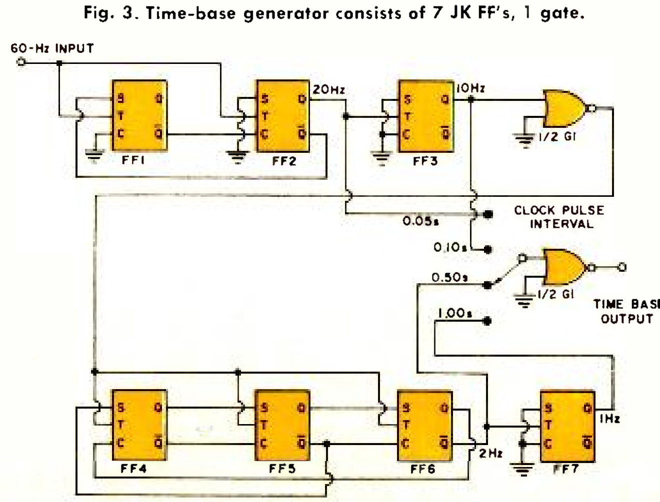
are all "0". This signifies the end of the timing cycle and *G*2's output steps to "1" driving the counter output to "0" regardless of the signal level from *G*1. At the end of the timing cycle, the control section switches S and C of *FF*1 to the "1" level and resets the FF's. The counter is now ready for the initiation of another timing cycle.

Control Section

The Control section stops and resets the counter at the end of the timing cycle. These functions occur when *FF*6 changes to the "1" state coincident with the "1-to-0" transition at the Counter Output. When *FF*6 changes to the "1" state, S and C inputs of *FF*1 are raised to the "1" level and *FF*1 can no longer be toggled by the incoming CP's from the time-base generator. Output Q of *FF*6 drops to "0" and *G*3's output steps to "1", resetting the counter.

Before the timing cycle can be started, $\overline{Q}$ of *FF*5 must be at the "1" level. This is done by momentarily depressing the Enable button, resetting *FF*5. Timing is initiated by momentarily depressing the Start button, resetting *FF*6 to the "0" state; S and C of *FF*1 drop to the "0" level, and the reset voltage is removed from P of all the counter FF's. The cycle begins (the Counter Output steps to the "1" level) when the next CP arrives at *FF*1. *FF*5 is toggled to the "1" state (by *G*1) and the enabling voltage from *FF*5 is removed from the Start button.

Fig. 3. Time-base generator consists of 7 JK FF's, 1 gate.



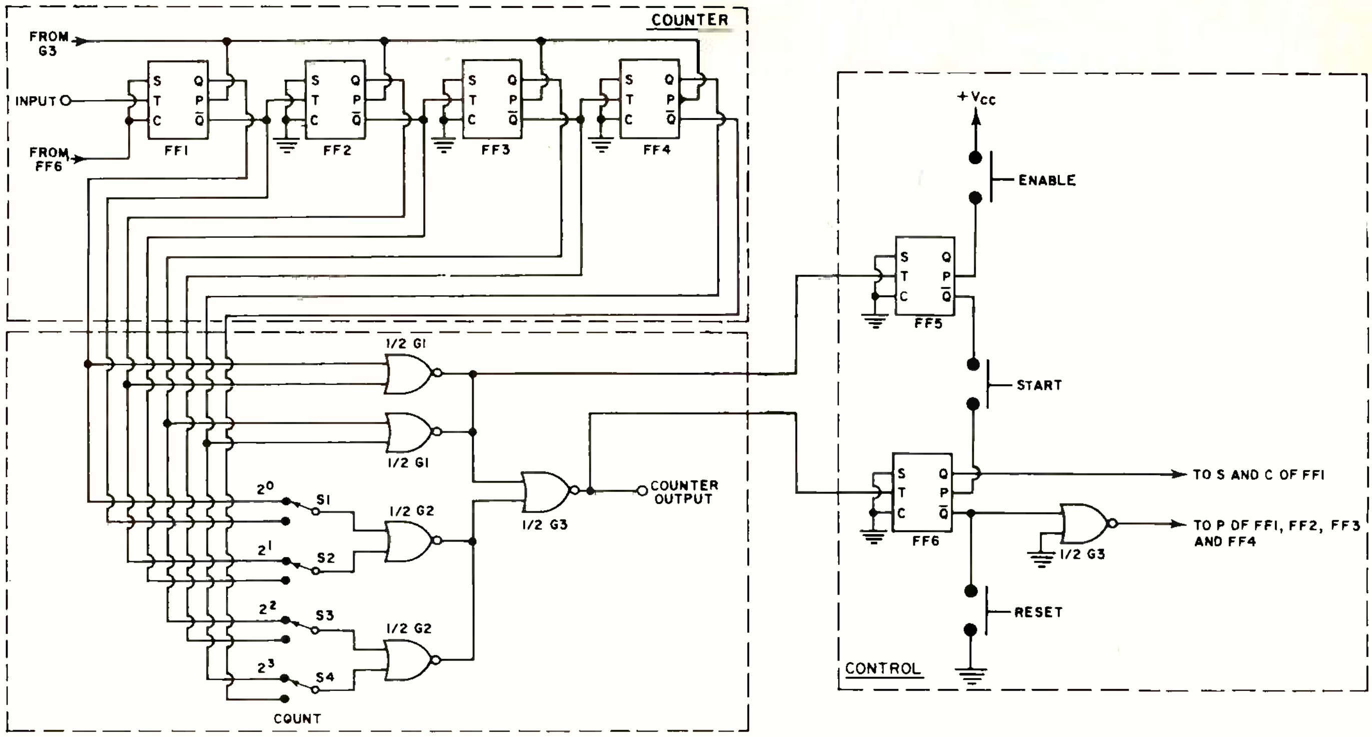


Fig. 4. Decoding section with its 2½ gates and the counter and control sections work together to form the interval timer.

Fig. 6 is a simple circuit which conditions a 60-Hz line signal to provide clock pulses for the time-base generator. It's a *Fairchild* RTμL 9914 gate connected to operate as a Schmitt trigger. The series resistance (*R*1) limits the peak voltage at the gate input to 2 to 3½ volts; 330 ohms is correct for an input of 3.15 V r.m.s. taken from the center-tap of a 6.3-V filament transformer. *C*1 is a filter and *D*1 clamps the negative portion of the input wave to ground.

Modifications

The time-base generator controls the timing accuracy and the minimum timing interval. If moderate accuracy (and a single minimum timing interval) is acceptable, a simple multivibrator might serve as the generator. For greater timing accuracy, the 60-Hz power-line frequency or a crystal-controlled oscillator are logical choices. Either of these can be divided down to provide clock pulses at the desired intervals.

The counter, which specifies the maximum number of clock-pulse intervals making up a full timing cycle, has a capacity of 2^n-1 where n is the number of counter FF's. The counter capacity can be extended by adding more FF's (following *FF*4) and gates (paralleled with *G*1 and *G*2) to the circuit of Fig. 4. Up to 9 more FF's may be added to extend the total count to 8191. In this instance, connect the outputs of the added gates to the outputs of the existing gates (*G*1 and *G*2), but leave pin 8 of the added gates disconnected. If more than one FF is added, G3 in Fig. 4 should be replaced by a *Fairchild* RTμL 9900 medium-power buffer.

Construction

Pin 8 of each IC package in Figs. 3 and 4 (and $+V_{cc}$ in Fig. 4) is connected to +3.6 V d.c. The power supply must be capable of delivering 400 mA, with low ripple and ±10% voltage regulation. Pin 4 of each IC package is grounded and pin 6 (Preset) of each FF is grounded unless shown otherwise. The "0" level at the Counter Output terminal is 0.1 V d.c. and the "1" level is 1.7 d.c. open circuit or 1.3 V d.c. across 470 ohms. ▲

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2. Lancaster, Donald E.: "Using New Low-Cost Integrated Circuits", ELECTRONICS WORLD, March 1966.
3. Steinbach, Donald L.: "IC Frequency Dividers & Counters" Parts 1 & 2, ELECTRONICS WORLD, December 1968 & January 1969.

Fig. 5. Waveforms at the outputs of each counter flip-flop.

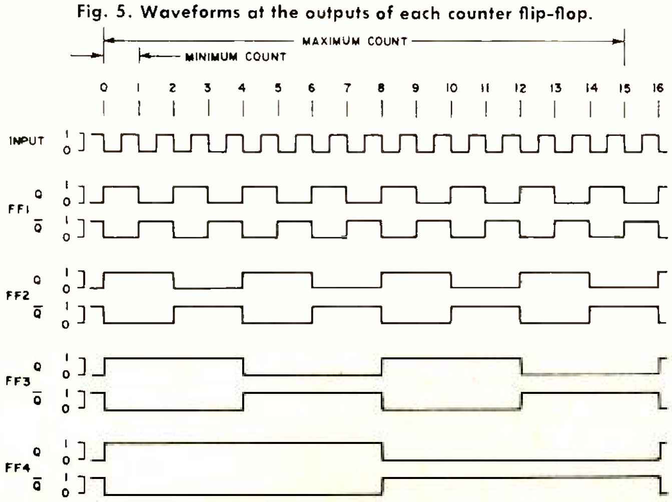
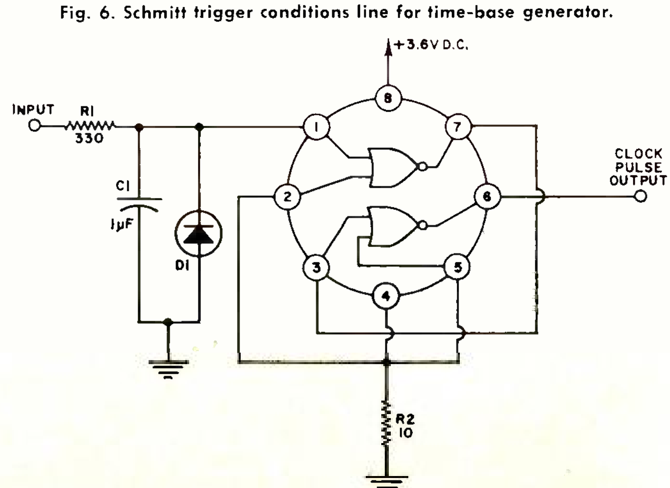


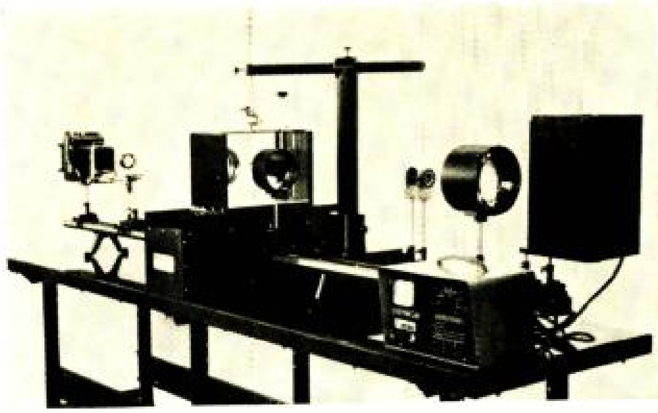
Fig. 6. Schmitt trigger conditions line for time-base generator.



ULTRASONIC WAVES MADE VISIBLE

By MILTON S. SNITZER/ Technical Editor

Visual and photographic examination of ultrasonic energy is made possible with this new schlieren optical system.



Arrangement of components in system. Cost is about $6700.

ENGINEERS and technicians working with ultrasonics in the past have had to work "in the dark" since ultrasonic energy is invisible. With this newly available optical system, it is now possible to actually "see" the ultrasonic beam produced by a search unit. Designers studying the performance of these ultrasonic transducers can examine the kind of sound beam produced and can see just what happens to it as they attempt to alter its shape or reflect it from various surfaces. In addition to possible use by metallurgists, physicists, and nuclear and aerospace researchers, engineering schools and universities who want to show their students the action of ultrasonic beams will find the system useful. Although in the past ultrasonic waves have been made visible in the lab, the system shown here is believed to be the first that is commercially available.

The setup is described as a *schlieren system*. Schlieren are regions in a transparent medium with a different density or refractive index than the rest of the material. This results in pressure or other differences that can be detected by photographing the passage of a beam of light through the material. The shock waves produced by a rocket being tested in a wind tunnel result in such patterns.

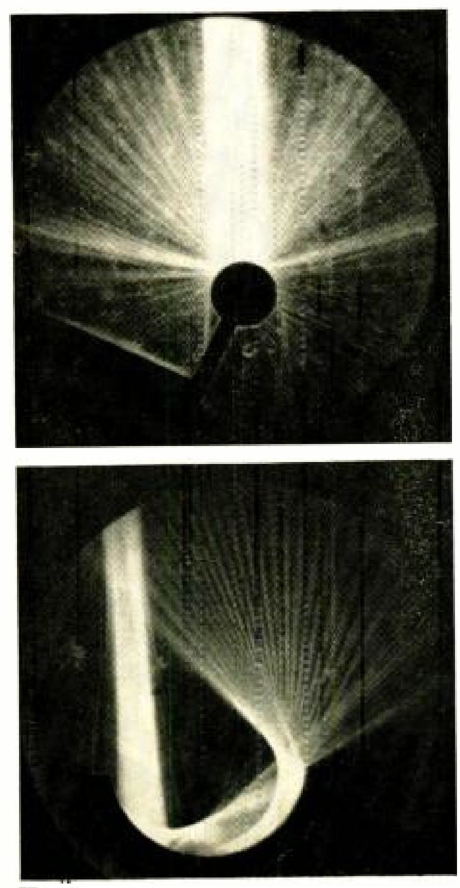
In the case of this ultrasonic system, the sound beam changes the refractive index of water in a transparent tank. When a beam of light is passed through the water, only the bent or diffracted light is used to produce a visible image on a ground-glass screen or on a camera film.

The setup consists of a series of carefully aligned optical stages that are mounted on a rigid platform. The ultrasonic search unit that is being checked is placed on an adjustable mount and submerged in a special water tank that has optical glass sides. The tank measures 14″ x 9½″ x 7½″.

A variable-intensity light source (in the black box at the extreme right in the photo and at the right in the diagram) produces the visible or photographed pattern. The light passes through a number of openings and lenses as well as through the water in the transparent immersion tank.

When the ultrasonic transducer or search unit is not operating, the water is undisturbed. The light beam is also undisturbed as it passes through, and it ends up focused on a small, opaque "dot" of material. The dot blocks the light entirely from the ground-glass screen or photographic film. When the search unit is turned on, it produces an ultrasonic sound pattern in the water. This alters the refraction index of the liquid where the ultrasonic energy is. The disturbance is not visible in the water. However, it results in a bending of the light beam, causing it to miss the opaque dot and land on the ground-glass screen where the pattern can be seen. A film pack can be substituted for the screen.

The schlieren system's ability to make visible sound patterns will be useful to researchers and designers in the field of ultrasonic non-destructive testing for observing the behavior of incident, refracted, and reflected sound energy. This information can save time in developing ultrasonic transducers and inspection techniques. The cost of the system is approximately $6700; it is available from *Automation Industries, Inc.*, Boulder, Colorado. ▲



(Top) Ultrasonic sound beam comes down from top, strikes metal ball, and is scattered in all directions. (Bottom) The beam comes down, enters inside curvature of a tube cut in half, and is deflected upward. Fan-shaped spread is due to the interference effects.

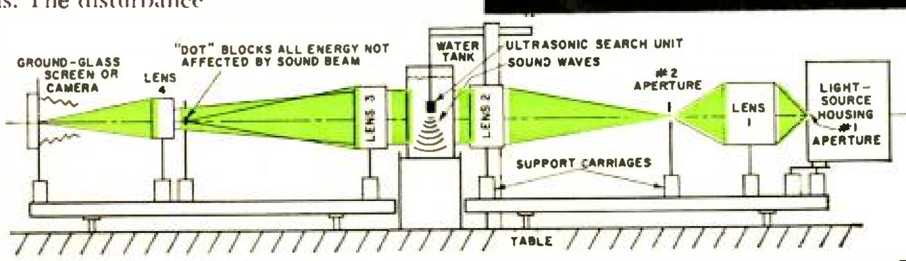
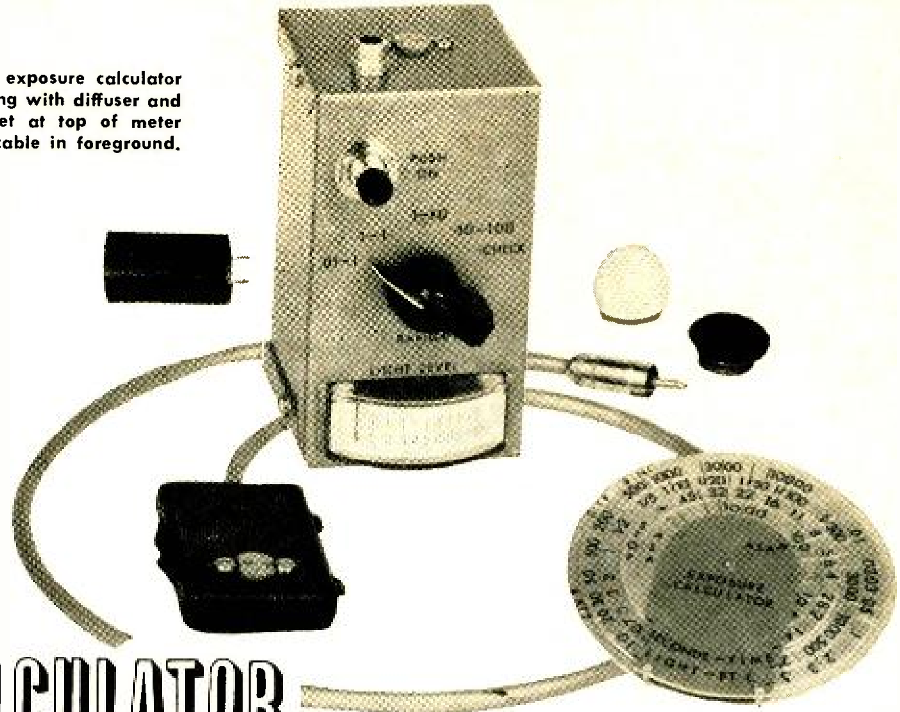


Diagram showing operation of system. Ultrasonic waves in water tank diffract light coming from right, causing light to miss the "dot" (or blocking aperture) and produce pattern of invisible sound waves on ground-glass screen or film.

Light meter constructed by author along with exposure calculator at right. Photocell, shown beside the meter along with diffuser and attenuator, may either be plugged into socket at top of meter housing or it may be plugged into extension cable in foreground.



design of a LIGHT METER & EXPOSURE CALCULATOR

By JOHN LEE BARNUM

An extremely sensitive photo light meter that can provide proper night-time exposure data and serve as enlarging meter for printing. Photocell is used with operational amplifier to provide four ranges.

THE light meter described here is an extremely versatile, multipurpose unit. It may be used as a very sensitive exposure meter for low-light-level night photography, as a photographic enlarging meter, as a conventional reflected-light exposure meter, or as an incident-light exposure meter for difficult lighting situations.

The unit employs a cadmium sulfide photocell and a simple four-transistor differential amplifier. Four electronically selectable ranges provide 0.01-0.1, 0.1-1, 1-10, and 10-100 footcandle incident-light readings. A mask attenuator is used for reflected-light measurements and a spherical diffuser lens for the photocell makes possible average value incident-light readings where more than one source of illumination is involved.

Camera exposure settings are obtained by setting the light value indicated by the meter on the exposure calculator. Exposure times ranging from 1/1000th of a second to 1 hour and *f*-stop settings from 1.0 to 45 may then be read directly for any film speed from ASA 1 to ASA 10,000. Different light set points on the calculator account for incident readings made with the photocell open, reflected readings made with the attenuator mask, and readings of incident light made with the diffuser.

A "Check" position is provided to give instant verification of proper performance. A full-scale indication on the meter with the photocell removed and the range switch in the "Check" position indicates that both batteries are good and that the differential amplifier is operating.

Battery life should be excellent. The 9-volt battery may discharge to as low as 6 volts (under a 20-mA load) and the unit will still function virtually perfectly on all scales. Battery drain is a maximum for both batteries on the higher light ranges. A maximum drain of 16 to 18 mA is encountered at light levels of 100 footcandles (for both batteries). At the lower light levels the current drain from the 9-volt battery decreases to about 1-2 mA. The drain on the 1.5-volt reference battery decreases to about 20 μA at 0.01 footcandle. The reference battery is the primary determinant of the accuracy of the light meter. For this reason, an alkaline-type battery is used. Such batteries offer vastly improved shelf-life and maintain voltage longer than carbon-zinc types. The "Check" function of the meter evaluates condition of the reference battery under a load condition.

Theory of Operation

The light-meter design employs a closed-loop operational amplifier whose gain is controlled by a photocell, a light-sensitive resistor. The amplifier input signal is a 1.5-volt d.c. level provided by the alkaline reference battery. Thus, the output voltage from the amplifier is equal to 1.5 volts multiplied by the amplifier gain. Since the gain of the amplifier is a function of the light striking the photocell, the output voltage is also a function of light level. The output voltage from the amplifier is read out on a meter; hence, we have a light meter.

The resistance of the photocell changes over a very wide range for light levels of 0.01 to 100 footcandles. At 0.01 footcandle the resistance is about 136k ohms, while at 100 footcandles it is about 90 ohms. To accommodate this very wide dynamic range, it is necessary to vary the value of

Table 1. Meter scale calibration data used for author's unit.

Light Level (footcandles)	Meter Current (mA)	Light Level (footcandles)	Meter Current (mA)
1	0.16	6	0.66
2	0.28	7	0.74
3	0.38	8	0.82
4	0.46	9	0.92
5	0.56	10	1.00

R_f, the feedback resistance, to maintain practical values of E_{out}. The range switch selects four values of R_f, such that for each decade range of light level, the output voltage of the amplifier always varies from about 0.8 to 5.0 volts.

Since it was decided to calibrate only one scale on the meter face, it was necessary to find a photocell whose characteristic resistance varied in a similar manner for all of the light ranges. The *Clairex* CL505-L was chosen since its resistance variation with light level is very nearly linear (on a log-log plot) over a wide range of light values. The resistance *versus* light level curve for the photocell is shown in Fig. 1.

Fig. 2 shows a plot of each decade light range in terms of meter voltage. The data given is calculated from the design-center values of R_f selected for the four ranges as follows: 0.01-0.1 fc, 66,000 ohms; 0.1-1 fc, 9600 ohms: 1-10 fc, 1500 ohms; and 10-100 fc, 300 ohms. Ideally, each of the four light ranges would plot as the same line. Variation between the lines represents a source of error if the meter face is calibrated with only one scale marking. However, the meter is calibrated using the average of the four ranges and the error introduced is not significant for most photographic applications.

The light meter uses four inexpensive plastic-encapsulated transistors and operates on a single positive supply voltage. A complete schematic diagram is shown in Fig. 3. The choice of transistors is not critical. The author used 2N2222's for *Q*1 and *Q*2, an MPS6516 for *Q*3, and an MPS6513 for *Q*4 simply because they happened to be on hand. However, the transistors specified in the parts list are better choices for performance and cost.

*Q*1 and *Q*2 are used as a differential pair, with the output signal taken from the collector of *Q*2. The differential voltage gain of *Q*1-*Q*2 is about 31. *Q*3 functions both as a d.c. level shifter and amplifier with a voltage gain of approximately 21. *Q*4 is connected as an emitter-follower and is used as the meter driver. It has a current gain equal to h_{FE} and a voltage gain of nearly unity. The output voltage taken at the emitter of *Q*4 is of opposite sense to the input voltage; that is, the over-all amplifier acts as an inverter and thus closed-loop, negative-feedback operation is made possible.

The total open-loop voltage gain (gain before feedback is applied) of the amplifier is 660 or 56 dB. It can be shown that, as long as the open-loop gain of an operational amplifier is at least 100 times greater than the desired closed-loop gain in the functional amplifier circuit, the closed-loop gain will be virtually independent of the open-loop gain. Here, the desired closed-loop gain varies from slightly less than unity to 3.33 (the actual closed-loop gain is a function of light level). Thus, in this application, the light-meter accuracy is not affected by open-loop gain variations such as might be caused by temperature, aging of components, etc.

The function of the capacitor, C1, is to provide a deliberate 6 dB/octave roll-off in the amplifier response, starting at about 16 Hz. This makes it certain the amplifier will not oscillate when used closed-loop as it is in the light meter.

Exposure Calculator Design

Designing the exposure calculator was not as difficult as it might at first appear. Essentially what is involved is recognizing the relationships existing among the various parameters involved; namely, exposure time, light level, film speed, and aperture size (*f*-stop). Film speed, exposure time, and light level are all related logarithmically. The *f*-stops are linearly related to the other three parameters mentioned.

The calculator consists of two sliders, movable with respect to one another and with respect to fixed set points. One of the sliders is laid out with light level and time both as logarithms set inversely to one another. An inverse relationship exists since time increases as light level decreases. The other slider is laid out with film speed plotted as a logarithm and *f*-stops plotted linearly with one *f*-stop being equal to one octave on the logarithmic film speed scale. The film-speed scale is laid out so as to be inversely proportional to light level. See Fig. 4 for a layout of the scales that are used.

The only remaining step, now that the basic relations have been established, is to determine an absolute magnitude of light level required to make a given photographic exposure. The light level and film speed for a known exposure are used to establish set points for the calculator. Once this is done, any other exposure, for any other light, *f*-stop, or film speed may be determined from the calculator. The set points for reflected (REF.) readings and for incident (DIF.) readings made with the diffuser to be described are obtained empirically. This is done by noting an exposure indicated by a reference light meter, setting this exposure on the exposure calculator, and then marking the light set point on the calculator beside the light value in footcandles indicated on the constructed light meter. The reference light meter must be calibrated to read both incident and reflected light in order to establish the light

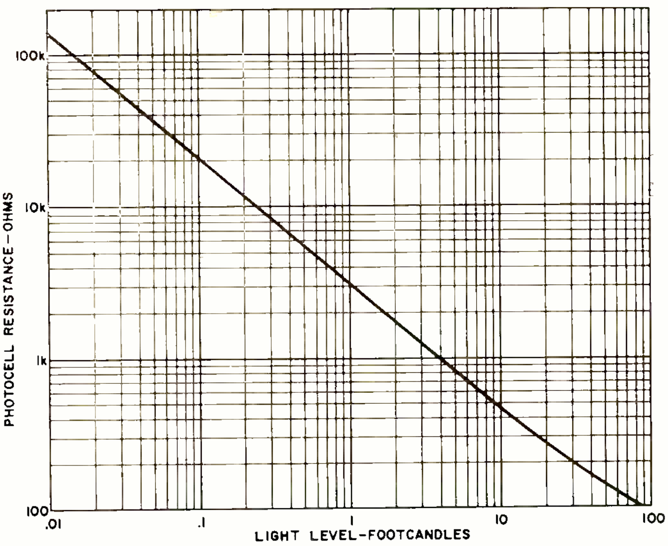
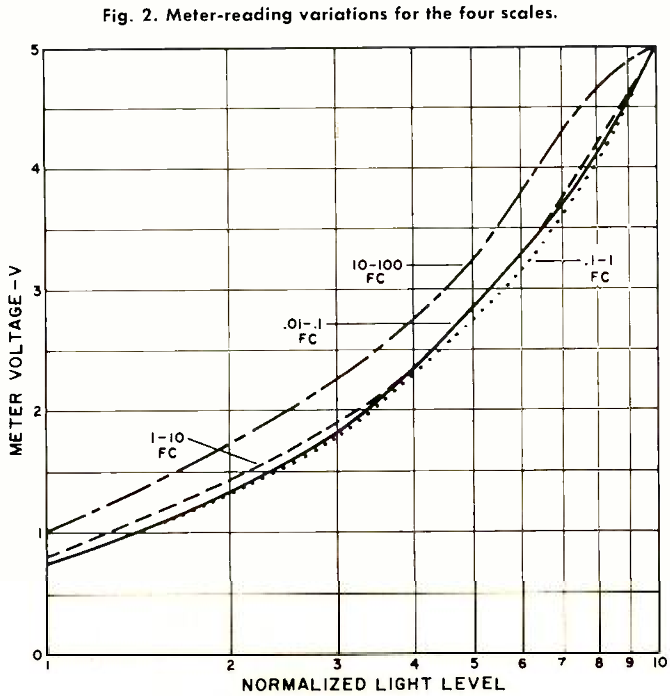
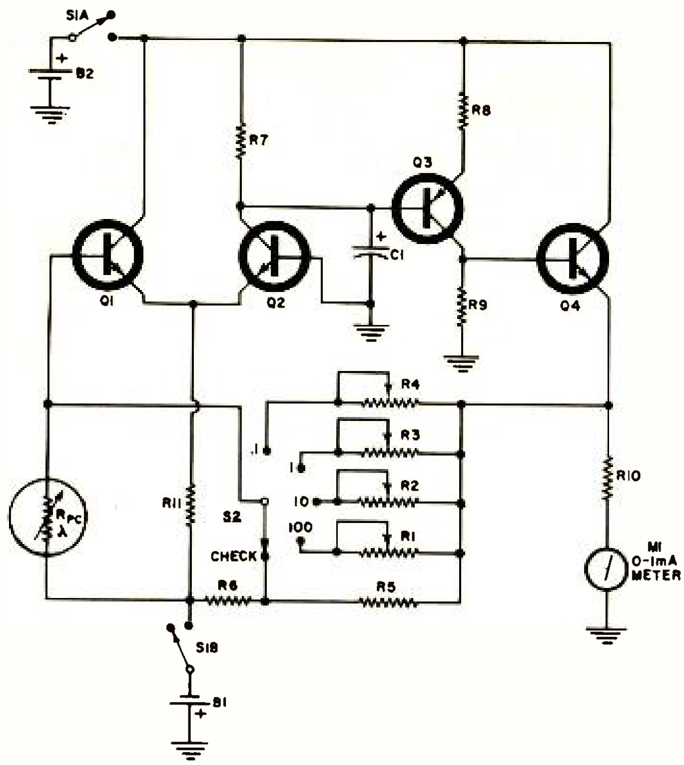


Fig. 1. Resistance variation of photocell versus light level.

Fig. 2. Meter-reading variations for the four scales.





R1—500 ohm miniature pot
R2—2500 ohm miniature pot
R3—25,000 ohm miniature pot
R4—100,000 ohm miniature pot
R5—10,000 ohm, 1/4 W res. ±2%
R6—3000 ohm, 1/4 W res. ±2%
R7—1000 ohm, 1/4 W res. ±5%
R8, R11—470 ohm, 1/4 W res. ±5%
R9—10,000 ohm, 1/4 W res. ±5%
R10—Adjust for full-scale meter reading with 5 volts across series combination of R10 and meter (3000 ohms in author's unit)
RPC—Clairex CL505-L photocell
C1— 10μF, 15 V miniature elec. capacitor
S1—D.p.s.t. push-switch, normally open
S2—S.p. 5-pos. selector switch
B1—1.5 V "C" size alkaline battery
B2—9.0 V transistor battery
Q1, Q2—2N3391
Q3—2N4126
Q4—2N3391
1—Chassis box 4" x 2 1/4" x 2 1/4"

Fig. 3. Complete schematic diagram of the light meter.

set points in this manner. Be sure the spherical diffuser is over the photocell when calibrating the incident-light set point.

Note that the open photocell light set point (INC.) should be the same for any light meter constructed and calibrated according to this article, but that the location of the diffuser light set point (DIF.) and the reflected light set point (REF.) will vary depending on the characteristics of the spherical diffuser and attenuator mask used. The diffuser used is a white plastic lens cap from a small pilot lamp socket, the type which accommodates a #47 pilot lamp. The attenuator mask has an aperture size of about 5/32 inch.

Construction

The author's unit was constructed in a 4" × 2¼" × 2¼" metal chassis box. After the front panel was drilled and the meter cut-out formed, dry-transfer lettering was applied.

Marking the meter scale is not difficult. However, extreme care must be taken not to damage the meter when removing the thin metal scale for remarking. The new scale markings are applied using dry-transfer lettering. The calibration points are "1's" and the scale numerals are applied directly below each calibration point. Table 1 gives a guide for remarking the meter scale. A marking template can be made for the particular meter used, employing the values shown. This would be required if the old markings are painted over.

The circuit may be wired on a prepunched terminal board, but a printed-circuit board is preferable. The unit constructed by the author employed an etched-copper circuit board.

The photocell probe is constructed using a plastic vial about ⅝" in diameter and 1¼" long. The vial should be about ½" to ¾" longer than the photocell to permit attaching the photocell masks and spherical diffuser.

Two small holes are punched in the bottom of the vial to accommodate the leads of the photocell. The photocell may be secured with glue or epoxy cement. Cut the leads on the photocell so that they extend ⅜" beyond the bottom of the vial. Do not cut the leads too short or the photocell probe assembly will not fit firmly when plugged into the light meter probe socket.

After the cement is thoroughly dry, paint the exterior of the probe assembly with black spray paint. Cover the wire leads and the photocell end of the vial when painting.

The calculator constructed by the author was made from rotatable aluminum discs, as shown in the photo. Scales were scribed following the markings given in Fig. 4. Dry-transfer lettering was used. Thin plastic sheets were placed between the metal surfaces.

An extension cable allows the photocell light pickup to be used remotely from the light meter case. It is made from a small plastic box painted black, one which is as flat as possible while still allowing clearance for mounting the photocell socket. A length of coax cable is used which is plugged into the meter chassis box.

Test and Calibration

With the photocell probe *not* connected, place the range switch in the "Check" position and push the "Push-On" button, S1. The meter should read full-scale ("10"). Proper indication in this test verifies that the operational amplifier is functioning correctly.

Set each of the calibration potentiometers to approximately mid-range settings. Insert the photocell in the socket, place the range switch in the 10-100 position, and push the "Push-On" button. A meter indication should be obtained, the magnitude depending on the light level. If a full-scale reading is obtained, try a darker location. Place a sheet of black paper or other dark object over the end of the photocell. The meter reading (*Continued on page* 78)

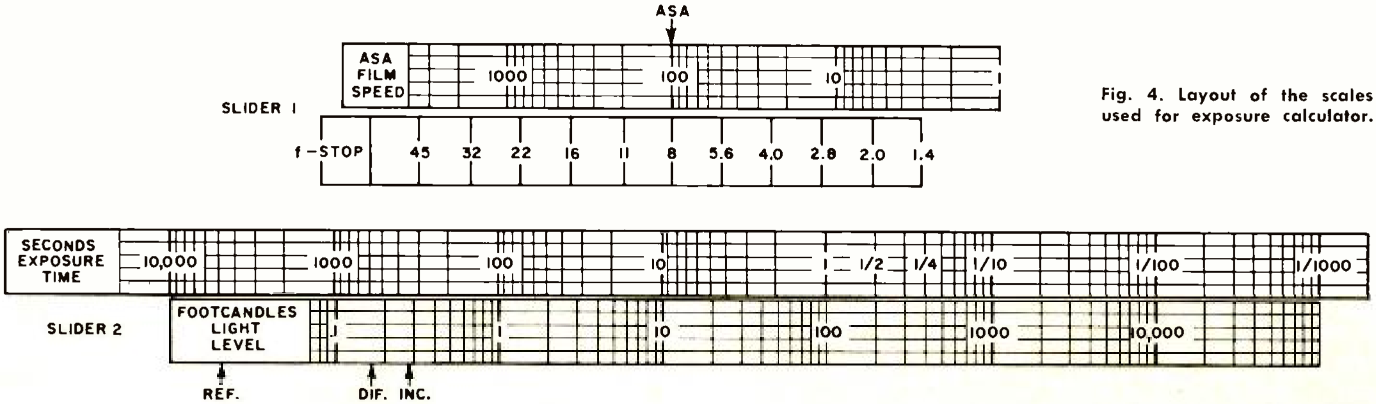
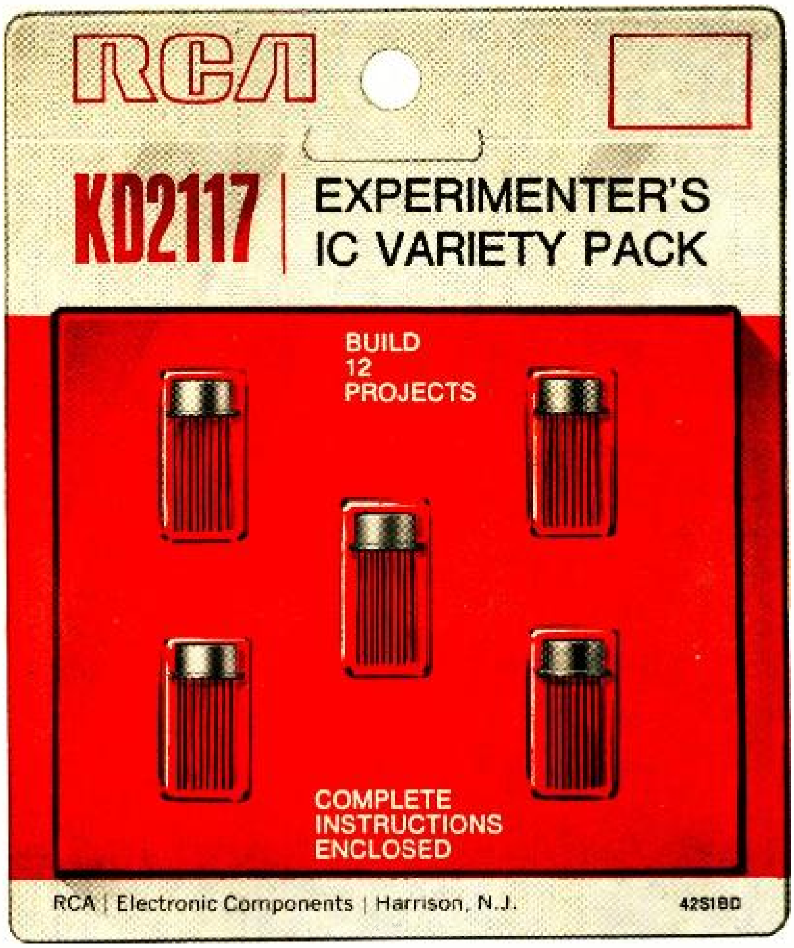


Fig. 4. Layout of the scales used for exposure calculator.



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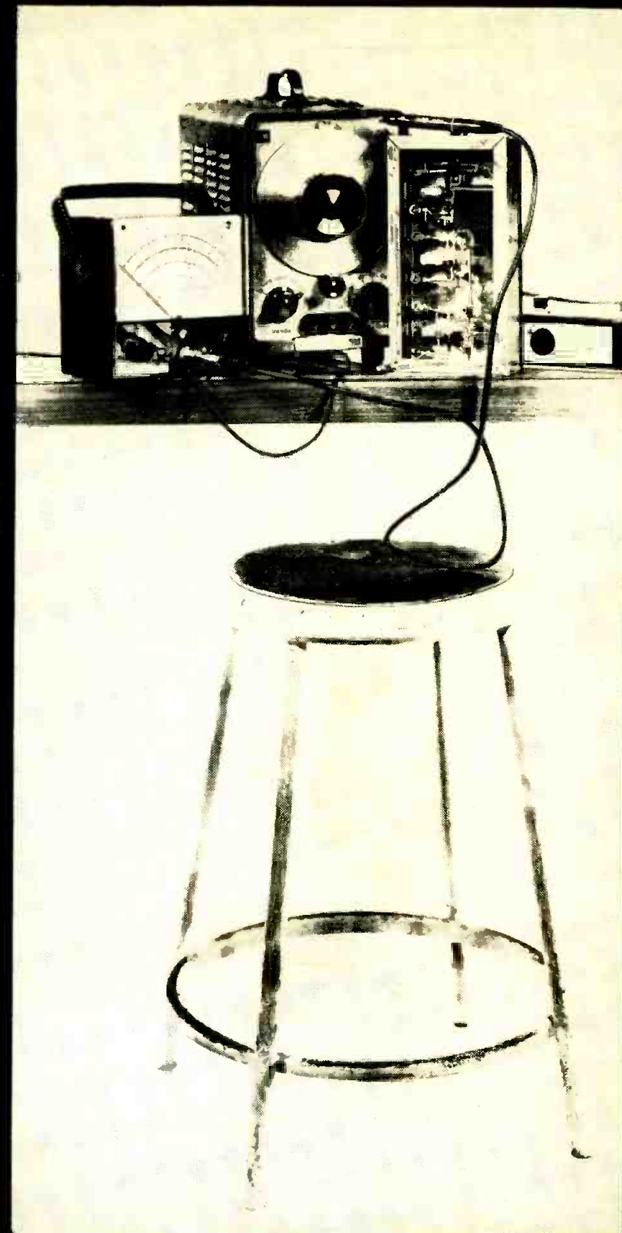


JOHN FRYE

A background in electronics is a great help in understanding neurophysiology.

ELECTRONICS AND PSYCHOLOGY

"BARNEY, how are you doing with that psychology course you're taking at the university extension center over at Kokomo?" Mac asked his assistant working at the service bench beside him. "Great, boss," Barney replied. "I'm the most interested student in the class."

"And so refreshingly modest," Mac retorted sarcastically. "I've never figured out, though, why you selected that subject. I'd have thought you'd have gone for math or physics or something like that. Why did you pick psychology?"

"Maybe I'd better let my mother tell you," Barney said with a grin. "While I was studying in the living room last evening, I heard a neighbor ask her that same question out in the kitchen. 'That boy,' Mom explained, 'has been taking things apart to see what makes them tick ever since he learned to toddle, and I just suppose he finally got around to wondering what makes *him* tick.'

"That's about as good an answer as I can give you, but let me straighten you out on that 'modesty' bit: I didn't say I was the *best* student in the class; I said I was the most interested. And the reason I'm interested is that we're studying the nervous system and I keep discovering oodles of exciting similarities between this system and the electronic components and circuits with which we work."

"Oh come *on!* You're not going to resurrect that tired old analogy of how much the brain is like a computer, are you?"

"Not yet, but give me time. Remember this is only Psychology I. I'm talking about comparisons on a component-to-component and function-to-function basis."

Mac leaned back against the wall and lit his pipe. "All right," he said as he blew out the match with an air of exaggerated resignation, "get it out of your system. You're busting to do so, and you're not going to be any good at the bench until you've had a chance to tell what you've learned."

"That's what I like—an understanding boss," Barney answered, dropping the test prods with alacrity and heaving himself up on the bench. "To start, psychology uses our 'black box' approach to acquiring information. The psychologists call it *behaviorism*, but it employs the same principles we use to determine: (a) what components exist inside an opaque sealed box, and (b) how these components are wired together. We do this by feeding various types of currents into the box and examining the currents and voltages that come back out.

"For centuries before 1913 it had been taken for granted that a person knows what goes on in his own mind directly, that he is conscious of his own consciousness. In that year John B. Watson cleaned house and threw out mental processes from psychology. He said the only thing a psychologist could be sure of is what a man or animal *does*—in short, how he behaves. Watson denied the scientific value of *introspection*, the direct observation of one's own mental processes. He felt this was about as trustworthy as having a bank examine its own books. Behaviorism, which he founded, treats the mind and body as a black box. Stimuli can be observed going into it, or selected stimuli can be deliberately fed into it, and the resulting behavior can then be observed. From this, educated guesses can be made as to what takes place inside."

"Do all psychologists agree with this?"

"Oh you dreamer! A consensus among psychologists on a theory is as rare as one among fashion designers on the proper height for skirts."

"You mentioned components in the nervous system that reminded you of electronic components. Tell me about those."

"Okay, but I don't think I need belabor the similarity between auditory receptors and microphones, visual receptors and photocells, or heat receptors on the skin's surface and thermocouples. In each instance the sensory nerve and the electronic device change, respectively, sound, light, and heat into electrical impulses. In the body these impulses travel along nerves or *neurons*, and I find tracking an impulse along such a pathway as fascinating and as full of surprises as reading a good whodunit.

"In the first place, it takes about ten billion neurons to 'wire' a human being. They are microscopic in cross section but vary in length from a fraction of a millimeter to more than a meter. They are packed together by the thousands to form the macroscopic structures of nerves, spinal column, and brain. A neuron is like a diode in that it allows an impulse to pass through it in only one direction. At the input end are one or more fibrils called *dendrites*. A single fibril going out of the sending end is called an *axon*."

"Hold it!" Mac interrupted. "Are you saying a nerve and a neuron are not the same thing?"

"That's right. A neuron is the single cell body, while a nerve is made up of a bundle of the long fibers that grow out of the cell bodies—dendrites or axons or both. You can think of nerves as being the laced cables that tie together the units of the neuron switchboard."

"And I suppose an impulse, being electrical, zips along these nerves and neurons the way it would along any other conductor."

"It's not all that simple. The impulse is both an electrical and chemical change that sweeps across the neuron at a fast but limited speed. But more about that later. It doesn't travel the same way in a dendrite that it does in a cell body or axon. A dendrite conducts 'decrementally.' That means it acts like a lossy transmission line; the impulse is attenuated as it moves along the dendrite. Unless the impulse is strong to begin with, it may disappear altogether before it reaches the cell body. The cell body and axon, however, work on the all-or-none principle. When excited enough to fire, they expend all their accumulated energy without decrement. The difference is that between a bow and arrow and a shotgun. With the former, the harder you pull the bowstring, the harder you shoot; but the shotgun shoots just as hard whether you jerk the trigger or squeeze it gently."

"That axon must fire the way a gaseous voltage-regulator tube does," Mac observed. "It's also an all-or-none conducting device."

Nature of the Impulse

"Precisely!" Barney applauded. "Now I've got you doing it. To get back to the speed of a neural impulse, let's take a closer look at the nature of the impulse. Picture the axon as a long tube of permeable material that, at rest, has positive sodium ions on the outside and negative ions on the inside. When an impulse comes from the cell body, the positive sodium ions near the neuron permeate the sheath and reduce the inside-outside potential to zero. To be painfully exact, there is a little overshoot in this process, and the potential actually reverses polarity briefly. This wave of sodium ion penetration moves out along the axon, while behind the travelling wavefront the sodium ions move back out of the axon to restore the normal resting state.

"This brings up an amusing circumstance. Psychologists do not know how the sodium ions are moved back out of the axon; so they 'invented' a *sodium pump* and say it moves them out! Remember how scientists, when they needed to explain how radio waves could travel through space, 'invented' the medium of *ether* to conduct the waves?"

"Yes, I suppose the sodium pump, the ether, and the purple cow all belong in the same imaginary museum. But for the last time: how fast does this impulse travel?"

"The speed varies from 1 meter a second in a small fiber to 120 meters a second in a large fiber."

"How does an impulse move from one neuron to another?"

"This takes place at junctions called *synapses*. Sometimes the synapse occurs where the axon of one neuron contacts a dendrite of another; in other instances the axon bypasses the dendrites and goes through a synapse directly to the cell body. The axon is branched and may contact several different neurons. In any event, the synapse is a variable-resistance conducting device. Not only does the resistance vary from synapse to synapse, but apparently the resistance of a given synapse can be varied by the learning process.

"Let me give you a ferinstance: suppose I burn my finger and the pain stimulus travels up an afferent neural path to the sensory portion of the cortex, then across through various internuncial paths in the brain to the motor area, and finally down an efferent path to muscles that produce an action. Let's say one time the action is to put my finger in my mouth. Another time I stick the finger under a stream of cold water. This last feels better; so all the synapses in the long-loop stimulus-response path that produced the cold water treatment are lowered in resistance, while the ones along the stick-the-finger-in-the-mouth path are increased in resistance. Of two possible responses to the painful stimulus, one has been reinforced by quicker escape from pain while the other has been inhibited by the longer duration of pain. This is one form of learning."

"If I understand you correctly, an axon connects through synapses with several different neurons. Through learning, it comes to fire only one of these. It is as though the axon were working through a multi-position single-pole switch that could be set by experience."

"Hey, you learn fast. Of course you understand this is a vastly over-simplified explanation. Let me tell you just one more thing I learned and then I'll get back to work.

The Arousal System

"The brain has a defense against distraction called the *arousal system* that has an uncanny similarity to the squelch circuit in a CB receiver. You know how you can set the squelch level so skip stations and other weak signals are kept from actuating the speaker; yet a strong wanted signal opens the squelch and is clearly heard. Well, the brain needs a squelch circuit, too. Without it every faint smell, every tiny sound, every body sensation—in short, all the important and unimportant information constantly bombarding the senses—would drive a person crazy, just as listening to an unsquelched CB receiver on Channel 9 these days will drive you nuts.

"A sensory impulse divides into two functions at the base of the brain. One, the *cue function*, is relayed on to the sensory portion of the cortex supposed to receive that particular sensation. The other, the *arousal function*, is fed to the arousal system deep in the brain stem. Its job is to provide a kind of adjustable bias to the sensory portion of the brain so that signals below a selected amplitude cannot get through. For example, the arousal state is very low when you're asleep, and faint or familiar sounds make no impression on the consciousness. But when the person is awake, alert, and vigilant, the arousal state is high and the smallest sound registers on the consciousness. You might say 'he is running with his squelch wide open.' "

"You've convinced me you're an interested student," Mac said, knocking the ashes from his pipe on the heel of his hand. "Now if you will just follow your psychology course with one in karate, you should be able to handle both our wily and our obstreperous customers! But now I think it's time for us to get back to work." ▲

Selecting a Tape Recorder

(*Continued from page* 39)

pre-recorded music tapes, a speed accuracy percentage of 1% or less is necessary. However, in situations where the recorder will be playing its own recordings, the speed accuracy figure may be larger than 1% without any noticeable effects.

Here are the usual applications for common tape speeds:

15 in/s—Generally used for radio broadcast tape production or phonograph-record mastering.

7½ in/s—Generally used for classical music and foreign-language tapes.

3¾ in/s—Generally used for voice and music (if frequency response is greater than 10,000 Hz and the flutter and wow are less than 0.3%).

1⅞ in/s—Generally used for speech only. *(Editor's Note: Although the author is not concerned with cassette-type recorders in this article, such machines with their special heads and tapes do a fairly good job on music up to about 9-10 kHz at a tape speed of 1⅞ in/s.)*

In general, the lowest possible speed is selected for recording purposes in order to conserve tape. For example, a 1200-foot tape will record in one direction for 30 minutes at a speed of 7½ inches per second, but at a speed of 3¾ in/s, a 1-hour program can be recorded one way on the same tape.

Tape recorders are labeled full-track, half-track, and quarter-track, depending on the width of the magnetic tracks (Fig. 2). Full-track recorders have virtually disappeared from the recorder market and are now being used only on some high-speed duplicators and a few special-purpose recorders where maximum signal-to-noise ratio is required.

The half-track recorder is generally available as a mono unit which allows a tape to be twin-tracked or played in both directions. Half-track stereo suffers from the disadvantage of one-way recording. At the end of the program, the tape must be rewound before the next program can be played.

The quarter-track recorder has the capability of being able to record four separate programs on one tape or two stereo programs (one in each direction, eliminating the need to rewind the tape). From an economical and operational standpoint, the quarter-track recorder represents the best buy because of the reduction in tape costs and the convenience of being able to turn the tape over rather than having to rewind the tape before playing another program.

Tape Decks

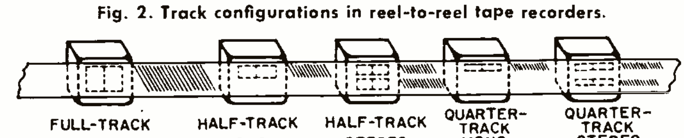
The tape deck is simply a tape recorder less power amplifiers and speakers. The output of the tape deck is at a preamp level. The electronics for the erase head of the unit is included.

In many applications the tape deck is ideal because of its reduced size, weight, and cost. In situations where the tape recorder is used frequently for making live recordings, dubbing from one recorder to another, or updating an existing sound system to include tape, a tape deck is preferable.

However, the tape deck has a disadvantage in its limited portability. This problem may be solved by getting a speaker-amplifier which can be used with the tape deck when the need arises for a complete sound system.

In making a final decision on a recorder, look for such features as easy-to-read vu meters, push-button solenoid-operated controls, and convenient location of jacks including microphone and preamp inputs, preamp outputs, and external speaker jacks. Also consider cost, weight, and appearance. The final decision should be based on a listening and operating demonstration of the models being considered. ▲

Fig. 2. Track configurations in reel-to-reel tape recorders.



REDISTRIBUTION OF COMPUTER MARKET IS FORECAST

THE separate pricing of computer software and services by *IBM* could open between $150 and $200 million in additional business to independent software companies during 1969, bringing their market to the $500 million level, or double the amount estimated to have been spent on independent software during 1968.

This was just one of the projections made during a one-day briefing session for investment analysts, conducted by "EDP Industry Report", published by *International Data Corporation* for executives concerned with the electronic data-processing industry.

During the opening session of the seminar, Patrick J. McGovern, president of *IDC*, estimated that the value of new computers and related peripheral equipment shipped by American manufacturers to customers throughout the world was approximately $7.2 billion in calendar 1968, up some 22% over the previous year. These shipments represented 14,700 computers, fewer than shipped in 1967, and reflect emphasis during 1968 on add-on equipment and large central processors.

As part of the briefing session, Mr. McGovern gave a marketplace appraisal of each of the major computer manufacturers, and indicated *IDC's* estimate of their portion of 1968 shipments. The figures, shown in the table below, reflect shipments throughout the world of new computers and new equipment added to computers They do not include machines refurbished by the manufacturers and shipped out to new users.

According to Mr. McGovern, although *IBM's* backlog of orders is lower than it has been in several years, orders for most of the other manufacturers are at an all-time high. The *IBM* situation, he pointed out, very likely stems from the fact that the company is delaying any announcements of additional System/360 computer models until after it has announced its new policies about pricing computer and software separately. ▲

Company	Shipment in $ millions	Percent
IBM	5,200	72.2
UNIVAC	380	5.3
Honeywell	340	4.7
Control Data	305	4.2
General Electric	280	3.9
RCA	225	3.1
Burroughs	170	2.4
NCR	170	2.4
Scientific Data	75	1.0
Digital Equip.	35	0.5
Others	20	0.3
Total	7,200	100.0

Rotary Thumbwheel Switches

(*Continued from page 41*)

counted on. Often the same switch parts that go into their military switches are used in the less-expensive industrial versions. The difference is that the expensive testing to meet the rigid military requirements is not performed on these components. Quality parts are used and the saving is passed on to the user.

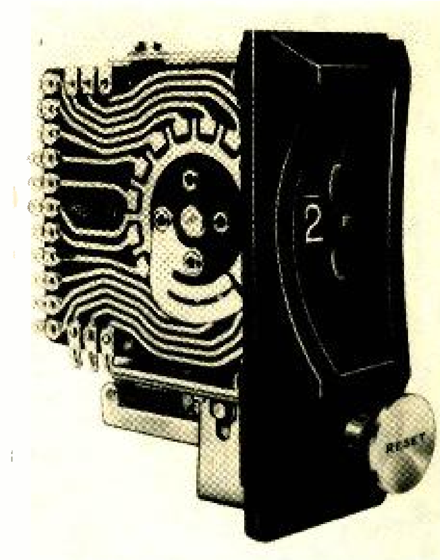
The Dot Chart

A form of interconnection chart, which we call a "dot chart" is useful in working with these switches (Fig. 3B). A dot appearing in a column indicates that the voltage tied to the common terminal (marked "C") will be routed through the switch to one or more of the four output terminals (in this example, "1", "2", "4", or "8"). In switch-position 6, for example, the common "C" is connected to output terminals "2" and "4." Thus a voltage of, say, 5 volts on the common line would appear at terminals "2" and "4." Terminals "1" and "8" would be at 0 volts. The binary number would then be 0110 or 6, its decimal equivalent.

Various manufacturers assign their own descriptive names to the dot chart. The *Digitran Company* of Pasadena calls it Electrical Output Configuration or Truth Table Format; *Chicago Dynamic Industries* of Chicago calls it Binary Code; while *Tech Laboratories* of Palisades Park, N.J. calls it a Truth Table. The purpose of the dot chart is to relate the dial reading to the connection between common lines and output terminals.

Prewired thumbwheel switch modules are available for special uses as resistance decades, capacitance decades, and voltage dividers, all with provisions for resistors and capacitors to be mounted on the printed-circuit board. Most switch manufacturers list other types of special codes, in addition to the binary coded decimal type that is being covered here.

The operating force (thumbwheel torque) required to turn the numbered wheel varies between 3 and 18 inch-ounces, depending on the manufacturer.



Printed-circuit wiring and construction of wiper can be seen in this resettable switch from Chicago Dynamic Industries.

Electrically, thumbwheel-switch ratings are comparable to most in-line types designed for small-signal control. For applications using a single common output such as with a decimal code, the non-switching current rating is typically 3 A (see Table 1). In coded-output applications, such as the decimal-to-binary conversion example used above, three or more wipers are used simultaneously and the current rating drops to 1 A at 117 V a.c. At 28 V d.c., the switch rating is typically 125 milliamps, depending on the manufacturer.

The switch resistance includes contact, wiring, and terminal resistance. Values are typically 100 milliohms maximum. The use of a printed circuit as an integral part of the switch assembly gives us a possible place to mount additional components.

The introduction of mass-production techniques and inexpensive industrial modules may extend the use of rotary thumbwheel switches into the appliance market. Aircraft and boating electronics equipment are using these switches now and undoubtedly other uses will follow. In addition, the test-equipment field as well as the computer areas have been using rotary thumbwheel switches for some time. ▲

Table 1. Typical rotary thumbwheel switch specifications.

PARAMETER	SPECIFICATION	COMMENTS
Contact rating	3 amperes 1 ampere	Non-switching decimal Non-switching coded
Contact resistance	100 milliohms	Initial value
Dielectric strength	1000 V a.c.	Maximum for 1 minute
Insulation resistance	500 megohms	Dry value
Life	100,000 revolutions	
Operating temperature	0° C to +85° C	Depends on materials
Contact carrier	Beryllium copper	

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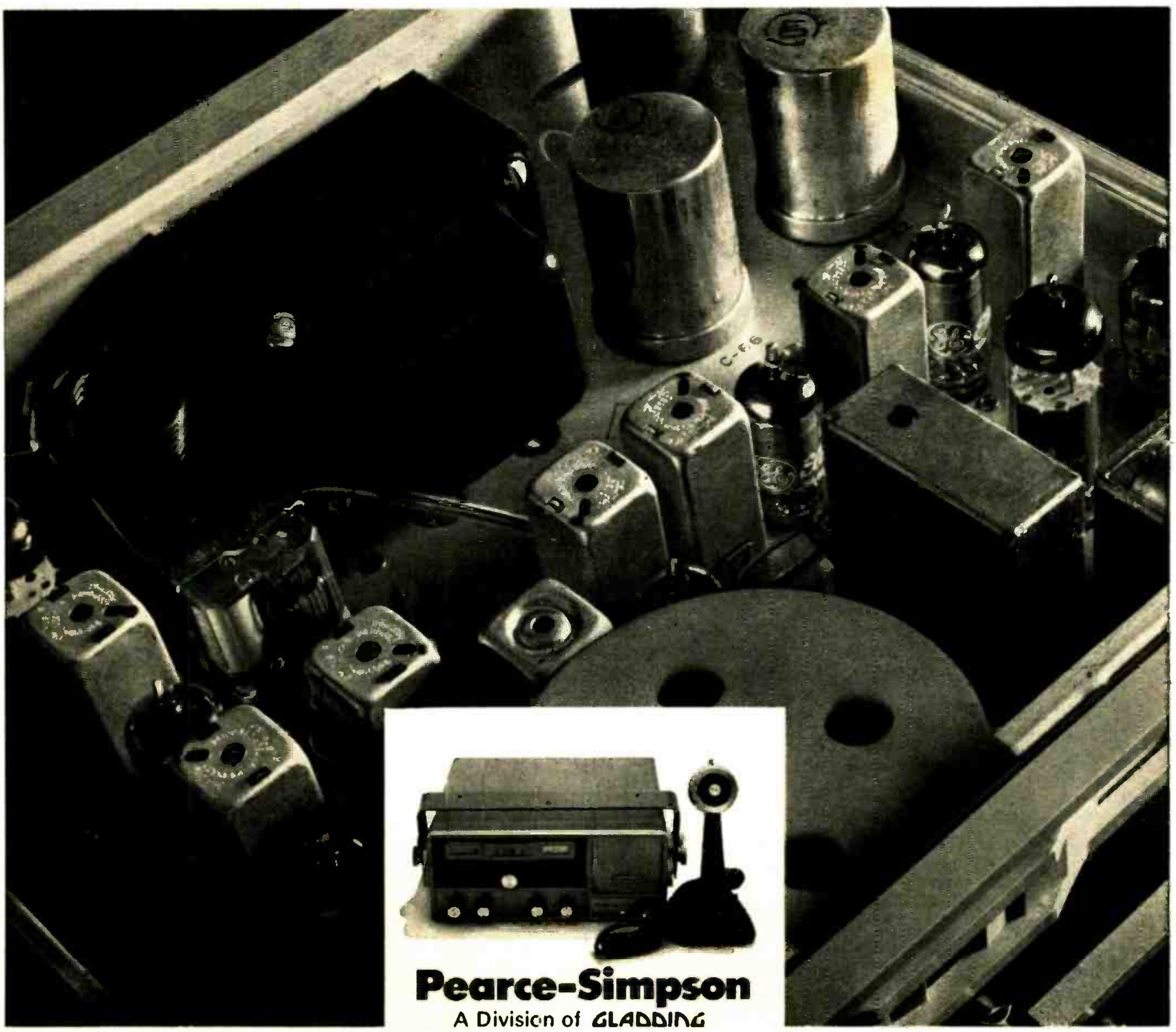
Our competitors hate our guts.



CIRCLE NO. 71 ON READER SERVICE PAGE

Radio Mirrors

(*Continued from page* 29)

Another area of difficulty in understanding the passive repeater is the matter of *beam spreading*. Many engineers and technicians believe the passive repeater must intercept all or most of the microwave beam between the half-power points (the −3 dB arc). After traversing a distance of 30 miles or so the half-power points of a 5-GHz microwave beam may be spread to almost one mile apart. The small antenna at an active repeater cannot even begin to intercept all the incident energy from a distant transmitter.

In the case of the passive repeater, it is the Fresnel zone radius energy that is intercepted and redirected. For a 6.0-GHz signal traveling over a sixty-mile path, the radius of the full first Fresnel zone at midpath (30 miles) is only 112 feet. And since it is seldom necessary to intercept even all of this energy, the construction of practical-size passive repeaters is relatively easy (Fig. 3).

It is necessary to keep the face of the passive repeater flat at microwave frequencies. This is mandatory since any distortions of the reflector face will degrade the signal. The face of the passive repeater must be flat to a tolerance of −⅛th wave length over the full face of the reflector. Notice that there is not a "+" tolerance factor. If there are any deviations from the flat reference point they must be concave rather than convex as a convexity would result in beam dispersal.

The communications engineer will design his system on the basis of calculating each path rather than immediately ruling out passive repeaters on the basis of archaic "rules of thumb." No rule of thumb can possibly take in all the variables including: transmitter power, parabolic antenna size, path lengths, receiver threshold levels, and operating frequency. Another variable that must be considered is that of channel loading. How many voice or data channels will be carried on the radio? Or will there be video information? Recognizing the variables involved, the knowledgeable engineer will compute his paths to determine if a passive repeater will work or if, indeed, an active repeater is needed.

The knowledgeable engineer or technician will also consider the economics of his active repeaters when they are necessary. Would it be less expensive to put the active repeater down by an existing access road (perhaps county or state maintained) and near existing power and then use a couple of passive repeaters on a nearby hilltop to provide the needed path clearance?

Companies that specialize in the manufacture and design of passive repeaters frequently have both literature and seminar training sessions for interested groups at nominal fees. Usually, a letter request is all that is required to obtain technical data. ▲

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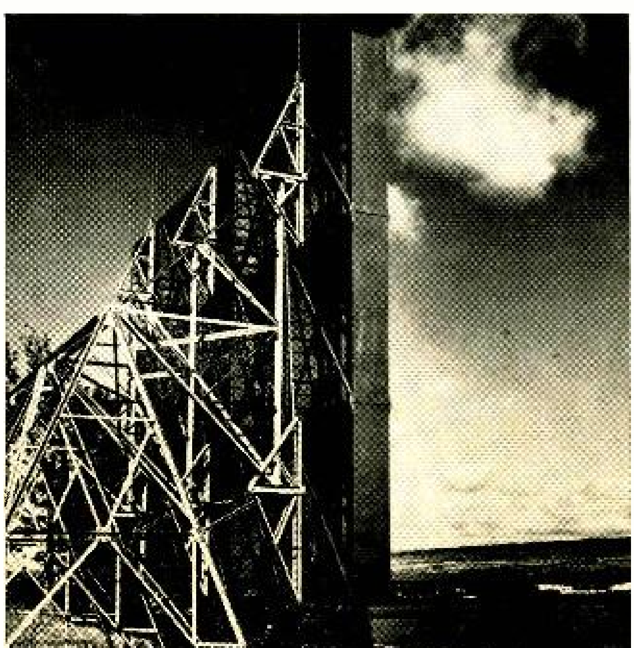
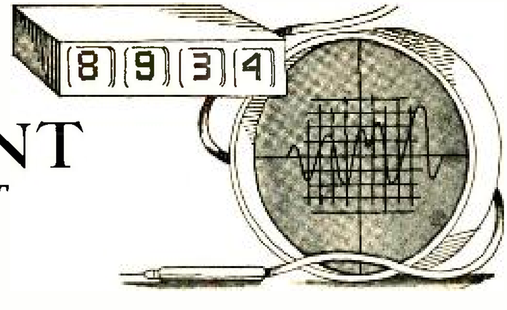


Radio mirrors are installed not only on snow-bound mountaintops but also in the tropics. This 30 by 40-ft repeater is installed on the island of Oahu and redirects a microwave signal capable of carrying 960 simultaneous voice conversations between Wahiawa and Honolulu, Oahu, Hawaii, a distance of over 23 miles. At a frequency of 6 GHz there cannot be any distortion greater than 0.164 inch over the full face of the radio mirror shown.

TEST EQUIPMENT
PRODUCT REPORT



Hickok Model CRO-5000 Oscilloscope
For copy of manufacturer's brochure, circle No. 25 on Reader Service Card.

HERE is a medium-priced, high-frequency laboratory oscilloscope designed by *Hickok* to go along with the company's digital measuring system. The scope, Model CRO-5000, sells for $650, which is somewhat less than other lab scopes with similar specifications. By simplifying some of the features and leaving out a few of the more exotic functions, the manufacturer was able to produce a professional instrument in this price range.

The scope is an all-solid-state instrument with a vertical bandwidth from d.c. to 25 MHz. The roll-off is gradual above this frequency so that high-frequency pulse distortion is minimized. As a matter of fact, the instrument is usable to over 50 MHz. Sweep speeds and trigger response are such that stable displays up to this frequency can be obtained with adequate horizontal expansion.

A built-in vertical delay line permits viewing the leading edge of pulse displays when internal triggering is used. The line delays the pulse for 50 nanoseconds so that the baseline and start of the pulse can be observed readily.

The vertical sensitivity is 10 mV/division and there are 12 calibrated sensitivity steps to accommodate a broad range of input voltages up to 50 V/div. The input circuit is protected against overload.

The cathode-ray tube used is a 4-inch flat-faced type with 3.8-kV accelerating potential to provide an intense, sharp trace. A precise, photographically produced graticule shows a 6 by 10 division display area, each division measuring 0.8 cm.

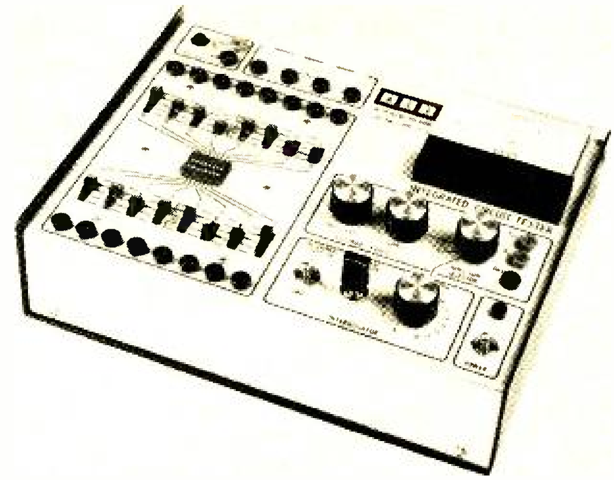
Horizontal amplifier response is also fairly broad, extending from d.c. to over 5 MHz. This makes the scope useful for X-Y display applications.

The manufacturer seems to have emphasized quality construction and mechanical ruggedness. Also, servicing and maintenance should be simplified by the accessibility of the components. A heavy-duty extruded aluminum closure provides a lightweight and rigid housing for the scope. Top, bottom, and side panels are removable so that all components on the glass-epoxy printed boards can be easily reached. There is plenty of internal shielding so that extraneous fields and r.f. interference will not be problems.

The scope is fairly small, measuring 11¼-in wide by 6⅞-in high by 19-in deep. It weighs 24 lbs and the front-panel carrying handles make it a readily portable instrument. The scope operates from the 117-volt a.c. line. ▲

AEI Instruments Model 101 IC Tester
For copy of manufacturer's brochure, circle No. 26 on Reader Service Card.

A NEW IC tester that permits you to test integrated circuits just as easily as a tube tester checks tubes has been introduced by *AEI*. The IC is simply plugged into the socket at the left on the front panel, the various switches are set, and the circuit is checked by observing the indicator lamps and readout



meter. A 16-pin IC socket holds both 14- and 16-pin IC's, and a separate adapter socket is available for accommodating IC's housed in flat-pack and TO-5 cans. Each of the leads is switchable to permit connections to the supply voltage, "1" level, ground, or no connection; there are pin jacks to permit access to the inputs and outputs for each pin connection. Four readout lamps can be patched into the various connections to indicate the logic state and the presence or absence of pulses. A pulser is also built into the instrument to furnish positive or negative input pulses for testing purposes.

Two independent power supplies, closely regulated and short-circuit-proof, furnish supply voltage and logic level voltage for the IC being tested. The supply voltage is adjustable up to 15.5 volts and the logic level voltage is adjustable up to 15 volts. The voltage scale of the readout meter is used to monitor these voltages.

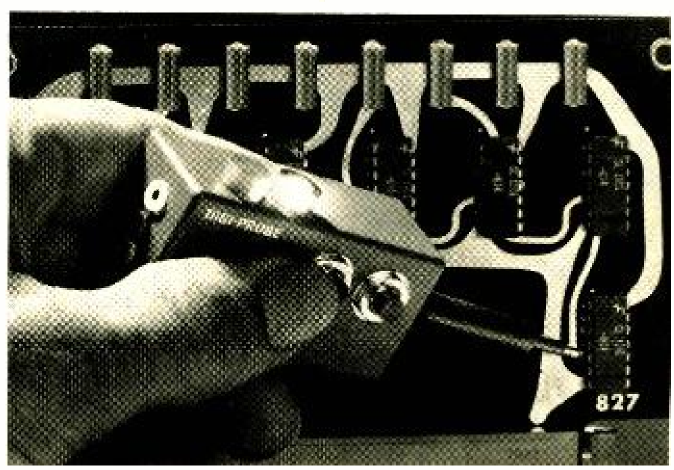
There is also an interrogator, which simply applies voltage or current to any of the pins of the IC under test.

This compact bench-top tester performs most of the tests that are essential to laboratory evaluation and failure analysis. The unit can be used to simulate IC functions under actual working conditions and to observe outputs as inputs are changed. The unit is completely self-contained so there is no need to tie up more elaborate IC testers used in quality control or production.

The tester is housed in a heavy-gauge aluminum case measuring 8½ × 11 × 3 inches and weighing only 6 lbs. It operates from a 115- or 230-volt a.c. power line. The Model 101 tester is priced at $275. ▲

Pulse Monitors Model 1210 Digital Test Probe

For copy of manufacturer's brochure, circle No. 27 on Reader Service Card.



PROBABLY the most common piece of test equipment around for tracing the pulses in digital circuits is the oscilloscope. Now the scope is fine for examining and measuring the pulses, but there certainly should be a simpler piece of test equipment that could be used if all we want to do is to find out if the pulses are present or not and what their polarity is.

At least two manufacturers are producing just such a simple tester which is in the form of a small, handy probe. The probes contain integrated circuits like the equipment they are being used to test. Readout is by means of one or more lamps that indicate the presence of the pulses. Depending on how the lamps flash, if at all, or the color of the lamp that is illuminated, the technician or engineer can do much simple troubleshooting and signal tracing throughout a digital circuit.

One of these probes, the *Hewlett-Packard* 10525A at $95, will work off pulses as short as 30 ns. The built-in lamp flashes on for a positive pulse, extinguishes for a negative pulse, burns at low brightness for a pulse train, burns brightly for a high logic state, and turns off for a low logic state.

Another such probe, which has just come to our attention, is the Digi-Probe Model 1210 from *Pulse Monitors, Inc.* (see photo). This probe also senses logic levels by reference to a standard voltage and it detects transitions between logic levels. An external power source of 5 V at 75 mA is required to operate the probe. This can be obtained directly from the IC circuitry being tested.

The Digi-Probe has an input impedance of greater than 75k ohms and can accommodate pulses to 24 volts. It can detect pulses as narrow as 25 ns and monitor a square-wave pulse train to 15 MHz. This test probe has two indicator lamps: a green one indicates low levels, negative pulses, or an out-of-phase condition; a red one indicates high levels, positive pulses, and an in-phase condition. There are two push-buttons, one to test and the other to clear, and a two-position mode switch all mounted in the rectangular 1 × 1¼ × 2¼ in case. Pin terminals on the back of the case permit logic signals from external circuits to be applied to the test probe to allow a time reference comparison to be made.

The Digi-Probe is suitable for production-line testing, field maintenance, as well as laboratory troubleshooting and engineering. Price of the probe is $89. ▲

STATIC ELECTRICITY MAY DAMAGE CAR RADIO

ACCORDING to Signalite, Inc., there may be enough static electricity in your body to blow out some of the transistors in your car radio if you happen to touch your radio antenna as you get out. Surge voltages up to 25,000 volts can flow into the receiver.

The company has come to the conclusion that many of the transistor radio receivers being returned for servicing have been damaged in this manner. These static voltages can be built up by normal friction between the driver's clothing and plastic seat-cover material.

According to the company, such static discharge problems can be solved by installing an inexpensive neon lamp between the antenna and the radio to shunt the high-voltage overload to ground before it reaches the transistors.

The neon lamp operates only when a high-voltage surge occurs and serves as constant protection. The company suggests that its dark-compensated LT-2-24 will do the job. ▲

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President

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NOT SATISFIED with your present income? The most practical thing you can do about it is "bone up" on your electronics, pass the FCC exam, and get your Government license.

The demand for licensed men is enormous. Ten years ago there were about 100,000 licensed communications stations, including those for police and fire departments, airlines, the merchant marine, pipelines, telephone companies, taxicabs, railroads, trucking firms, delivery services, and so on.

Today there are over a million such stations on the air, and the number is growing constantly. And according to Federal law, no one is permitted to operate or service such equipment without a Commercial FCC License or without being under the direct supervision of a licensed operator.

This has resulted in a gold mine of new business for licensed service technicians. A typical mobile radio service contract pays an average of about $100 a month. It's possible for one trained technician to maintain eight to ten such mobile systems. Some men cover as many as fifteen systems, each with perhaps a dozen units.

Coming Impact of UHF

This demand for licensed operators and service technicians will be boosted again in the next 5 years by the mushrooming of UHF television. To the 500 or so VHF television stations now in operation, several times that many UHF stations may be added by the licensing of UHF channels and the sale of 10 million all-channel sets per year.

Opportunities in Plants

And there are other exciting opportunities in aerospace industries, electronics manufacturers, telephone companies, and plants operated by electronic automation. Inside industrial plants like these, it's the licensed technician who is always considered first for promotion and in-plant training programs. The reason is simple. Passing the Federal government's FCC exam and getting your license is widely accepted proof that you know the fundamentals of electronics.

So why doesn't everybody who "tinkers" with electronic components get an FCC License and start cleaning up?

The answer: it's not that simple. The government's licensing exam is tough. In fact, an average of two out of every three men who take the FCC exam fail.

There is one way, however, of being pretty certain that you will pass the FCC exam. And that is to take one of the FCC home study courses offered by the Cleveland Institute of Electronics.

CIE courses are so effective that better than 9 out of every 10 CIE-trained graduates who take the exam pass it. That's why we can afford to back our courses with the iron-clad Warranty shown on the facing page: you get your FCC License or your money back.

There's a reason for this remarkable record. From the beginning, CIE has specialized in electronics courses designed for home study. We have developed techniques that make learning at home easy, even if you've had trouble studying before.

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Your CIE instructor gives his undivided personal attention to the lessons and questions you send in. It's like being the only student in his "class." He not only grades your work, he analyzes it. Even your correct answers can reveal misunderstandings he will help you clear up. And he mails back his corrections and comments the same day he receives your assignment, so you can read his notations while everything is still fresh in your mind.

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Matt Stuczynski, Senior Transmitter Operator, Radio Station WBOE

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CIRCLE NO. 117 ON READER SERVICE CARD

DUAL-RATE SAWTOOTH GENERATOR

By FRANK H. TOOKER

This UJT multivibrator generates two sawtooth signals whose rates can be varied independently.

DID you know a unijunction sawtooth-waveform generator, such as the one shown in Fig. 1, can be made to generate waveforms of two different repetition rates alternately, as illustrated in the diagram of Fig. 2? In this circuit, Q1 fires first, producing a cycle of one frequency; then Q2 fires and produces a cycle at another frequency.

The two repetition rates are independent, and determined by the effective *RC* values in the emitter circuit of each UJT. As far as the repetition rates are concerned, capacitors *C*1 and *C*2 operate as a single capacitor having a value equal to the two tied in series.

In this demonstration circuit, repetition rates are determined by the setting of potentiometer *R*3. Therefore, when the resistances in the emitter circuits of Q1 and Q2 are equal, the repetition rates will be equal. However, if the potentiometer is adjusted so that one UJT has a lower emitter resistance than the other, the circuit with the lower resistance will fire more rapidly. And of course, with *R*3 connected as shown, increasing the repetition rate of one UJT decreases the rate of the other. But if two potentiometers are used—one in the emitter circuit of each, the rates are independently adjusted.

As long as the value of *C*2 is equal to the value of *C*1, the amplitude of the output signal at the two repetition rates will be very nearly equal (Fig. 2A). However, if one capacitor is smaller than the other, the output signal amplitude coming from that side of the circuit will be lower and the output waveform is similar to that shown in Fig. 2B. (assuming *C*2 is smaller than *C*1 and Q2 has the higher repetition rate). The maximum practical ratio of the two capacitors (*C*2 to *C*1) is about 5:1. Beyond this point, the output waveform begins to resemble that shown in Fig. 2C.

The output signal is actually available at the junction of capacitors *C*1 and *C*2, but because this must be considered a relatively high impedance point, the signal is fed to an FET source-follower, Q3, where a much lower impedance is available at the source electrode. Resistor *R*4 is not part of the dual-rate sawtooth generator proper. It is Q3's gate-return resistor. Signals of rectangular waveform are available at base-2 of each of the two UJT's. The mark-to-space ratio of these signals depends on the ratio of the resistances in the emitter circuits.

A circuit producing the waveform shown in Fig. 2A may be used as a dual-rate horizontal sweep oscillator in an oscilloscope. In this event, the rectangular waveforms at base-2 of each of the UJT's may be used to operate electronic switches which, in turn, would apply the two signals being observed, alternately, to the scope's vertical amplifier.

The circuit may also be used as a novel tone generator for an electronic organ. In this case, the emitter resistor in one of the two unijunction transistors is selected to produce the lower or fundamental frequency; the other UJT would have a potentiometer in its emitter circuit which could be adjusted to produce either the fundamental, or any harmonic frequency desired. ▲

Fig. 1. Dual UJT multivibrator has low-impedance FET output.

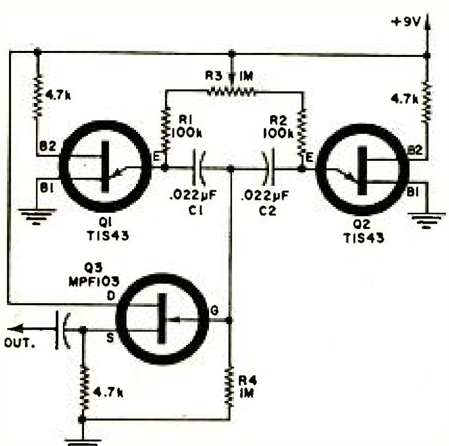
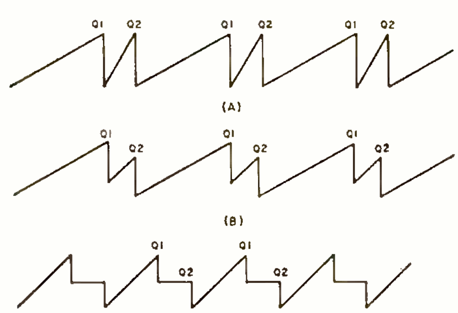


Fig. 2. (A) Waveforms when C1 equals C2 (Fig. 1). In (B) C2 is smaller than C1. (C) Capacitance ratio is greater than 5 to 1.



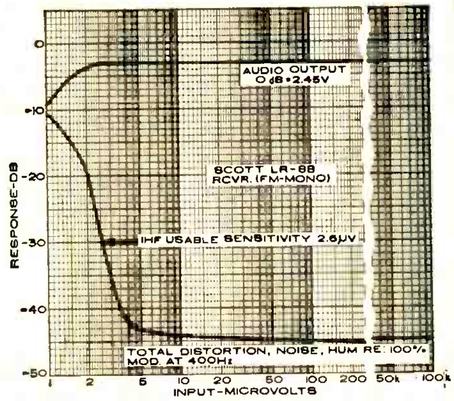
EW Lab Tested
(Continued from page 17)

tions, and wiring the controls and switches. Switches on the receiver chassis connect the tuning meters to appropriate circuit test points as an aid to alignment. Since the receiver is prealigned, it should operate satisfactorily without additional alignment, but to obtain maximum performance a series of optional alignment procedures may be performed covering the AM and FM tuners and multiplex (separation) adjustments.

A section of the general service notes in the manual contains detailed information for testing and replacing transistors, replacing the dial lights and drive cord, and similar maintenance procedures which may be required during the normal life of the receiver. For the benefit of the technically qualified user or service technician equipped with the proper test instruments, detailed alignment and test procedures are presented, covering all aspects of the receiver's performance.

A valuable feature of the manual is the section on basic AM/FM-receiver theory, audio-amplifier theory, and antenna installation hints. Considerable general background on high-fidelity sound reproduction is also included. We found the manual to be highly readable and informative, quite apart from its basic function of providing assembly instructions.

The receiver was tested after only the optional alignment without instruments. In general, it met its specifications so well that we did not feel that any benefit could result from an instrument alignment. The FM tuner had an IHF usable sensitivity of 2.6 microvolts, with distortion less than 0.6% at input signal levels of 10 μV or greater. The FM-stereo frequency response was

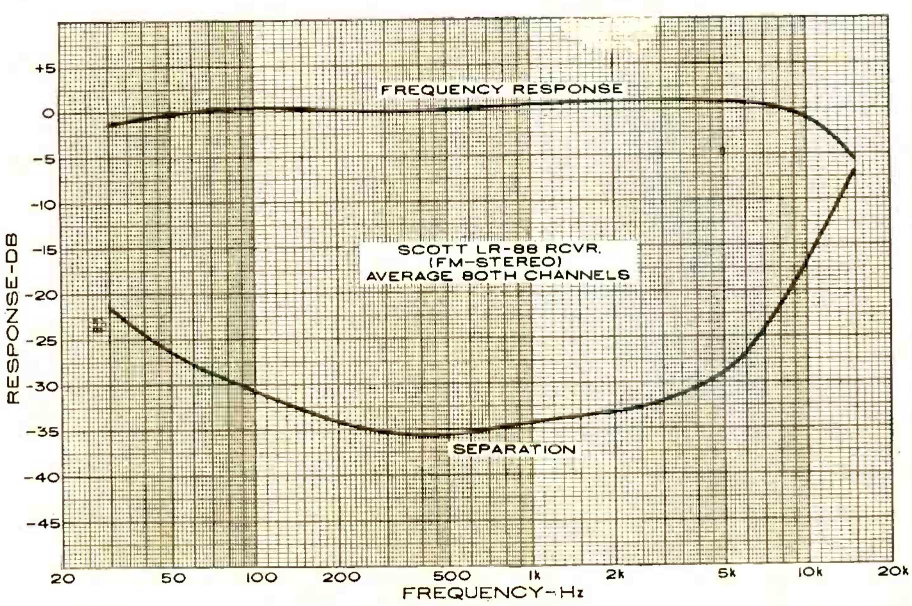


+1, −1.5 dB from 30 to 11,000 Hz, and down 6 dB at 15,000 Hz. The high-frequency rolloff was due to the inclusion of a 15-kHz low-pass filter, which eliminates any 19- or 38-kHz components in the stereo output that might cause beats with a tape recorder's bias oscillator. The slight loss of extreme highs is not audible. Channel separation exceeded 30 dB over much of the audio range.

The audio distortion at 30 watts per channel was about 1% from 60 to 20,000 Hz, increasing to 2% at 30 Hz. At half-power or less, the distortion was about 0.25% from 20 to 1000 Hz, and 0.5% to 1% at the highest audio frequencies. At 1000 Hz, the harmonic distortion was typically less than 0.35% from 0.1 watt to 25 watts, reaching 1% at 30 watts. The IM distortion was under 0.5% at levels of a fraction of a watt, 1% from 1 watt to 27 watts, and 2% at 30 watts.

The noise filter had a very gradual slope (6 dB/octave) beginning at about 3000 Hz. The RIAA equalization was very accurate, within ±1 dB from 20 to 20,000 Hz. Hum and noise were 66 dB below 10 watts on phono, and 75.5 dB below 10 watts on the high-level "Aux" input.

In listening tests, the LR-88 performed to our complete satisfaction. Its



CIRCLE NO. 83 ON READER SERVICE CARD →

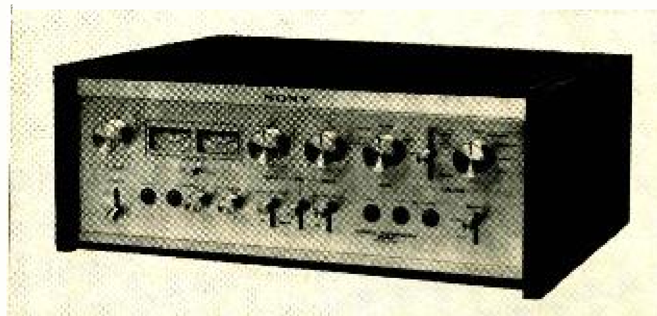
tuning was easy and non-critical, and it had all the "punch" one could desire, even when driving low-efficiency speakers. The interstation squelch circuit operated with a slight noise burst when tuning through a station.

The AM tuner was a pleasant surprise, in this day of almost universally mediocre AM reception. It recalled some of the earlier *Scott* AM tuners, which were among the best of their day. It was sensitive, yet had a quiet and noise-free background. The wide frequency response and low distortion of the LR-88 AM tuner came remarkably close to FM quality, although the difference was clearly audible. Although the tuner had a 10-kHz whistle filter, it did not appear to be fully effective, particularly under nighttime listening conditions, and the whistles marred the otherwise very listenable sound except on local stations.

The *Scott* LR-88 kit sells for $299.95. It is not inexpensive, but it does offer the builder an opportunity to learn something of the inner workings of a modern stereo receiver, pass some pleasant hours in its construction, and obtain a very good stereo receiver which should provide years of enjoyable listening. ▲

Sony TA-2000 Stereo Preamplifier

For copy of manufacturer's brochure, circle No. 24 on Reader Service Card.



THE better-quality high-fidelity amplifiers of a decade ago were usually in two parts—a preamplifier and a power amplifier. In modern solid-state amplifiers, problems of size, heat, and magnetic fields have been largely overcome, and one-piece integrated amplifiers are the rule today. But many critical audiophiles still prefer the greater flexibility possible with a two-unit amplifier. It is for this group that *Sony* has developed the Model TA-2000 solid-state stereo preamplifier and associated power amplifiers.

The TA-2000 appears to be similar in many respects to the preamplifier section of the manufacturer's TA-1120 integrated amplifier (reported on in January, 1967). It has step-type tone controls that assure precisely repeatable response characteristics, closely matched between the two channels. A front-panel switch enables the user to bypass the entire tone-control circuit. Also included are 50- and 9000-Hz filters, with 12-dB/octave slopes, and an expanded form of the double-switch input selector used in the TA-1120.

The two most often used inputs, "Tuner" and "Phono", are selected by a lever switch, which in its third position transfers controls to a five-position rotary switch. With this, one can select a second phono cartridge, tape head, microphone, or either of two high-level "Aux" inputs. Each input has its own level control in the rear of the amplifier, so that widely differing program sources can be matched in level.

A mode switch connects the TA-2000 for stereo, reversed-channel stereo, left plus right (mono), and either left or right inputs playing through both outputs. Two other positions activate each channel output individually for channel-level balancing. A balance control is on the front panel.

Viewed from the front, the most obvious distinguishing feature of the preamp is the pair of illuminated vu meters that monitor the two outputs. Their "zero vu" level corresponds to the nominal output of 1 volt, or to the reduced output of 0.3 volt if this is selected by a slide switch on the rear. A test button reduces meter sensitivity by 14 dB to permit measurement of stereo separation down to −34 dB.

Most of the input and output jacks are located in the rear of the TA-2000, including the tape inputs and outputs (a monitoring switch is on the front panel), two pairs of output jacks, and a center-channel output with its own level control. On the front panel are a pair of microphone jacks, the Aux-2 input jack, and a line-output jack. A stereo-headphone jack, with its own level control, is also on the panel. It accepts phones with an impedance of 600 ohms or higher. Low-impedance phones cannot be driven from the TA-2000. One pair of rear output jacks and the center-channel output are disconnected when either the phones or line output is in use, leaving the other pair of outputs for driving a second power amplifier.

The Phono-2 input has two sensitivities, selected by a slide switch in the rear. The Normal sensitivity, like that of the Phono-1 input, is rated at 1.2 millivolts. In the Low position, Phono-2 requires only 0.06 millivolt into a 200-ohm impedance for a 1-volt output. This is sufficient to handle low-output, moving-coil cartridges (such as the *Ortofon*) without a step-up transformer.

It should be apparent that the TA-2000 is an extraordinarily flexible preamp, perhaps unequaled in versatility by any other currently available model. Space does not permit more than this brief listing of a few of its control features. It offers the equivalent of a two-channel audio vacuum-tube voltmeter for phono-cartridge frequency-response and crosstalk measurements. The comprehensive manual contains full details on using the meters for audio measurements. Although they are not quite as accurate or as easily read as laboratory-type meters, they are certainly satisfactory for system-performance verification.

The performance specifications are presented in great detail in the manual, including all pertinent test conditions. To the extent permitted by our instruments and test methods, we verified all of them. The TA-2000 proved to be essentially distortionless, as one would expect from a well-designed, low-level amplifier. The maximum rated output is 2.5 volts, and below 3 volts the harmonic and IM distortions did not exceed the 0.06-percent residual distortion of our test instruments. The *Sony* rating of 0.03 to 0.05 percent distortion at a 1-volt output seems to be quite conservative.

Hum and noise were also exceptionally low. At the high-level inputs, they were undetectable, at least 100 dB below a 1-volt output. At the phono and tape-head inputs, the hiss was 63 and 66 dB below 1 volt, which is inaudible under any home-listening condition we can imagine. There was no detectable crosstalk between inputs when they were normally terminated. *Sony* provides shorting plugs for unused low-level inputs to prevent any hum or noise pick-up when switching through them.

The TA-2000's tone-control characteristics have been chosen wisely. Moderate corrections of low- or high-frequency response can be made with no effect on the mid-frequency range, and one can apply rather large amounts of boost or cut without modifying the response in the 300 to 4000 Hz region or introducing an unnatural sound quality. There is no loudness compensation as such. but the tone controls are quite capable of performing this function if desired.

The RIAA phono equalization was within +2.5, −0.5 dB from 20 to 20,000 Hz which is beyond the defined 30 to 15,000 Hz range. The slight rise occurred in the 30 to 60-Hz region, where many preamplifiers prove to be deficient in output. The NAB tape-head equalization was very flat, being down 0.5 dB at 33 and 20,000 Hz. It could be adjusted over a 5-dB range in the high-frequency area to complement the characteristics of particular tape heads. Volume-control tracking was excellent, with less than a 1-dB difference between channels over a 50-dB control range.

The preamplifier, despite its very high phono gain, can tolerate large signal inputs without overloading. On the normal Phono-1 inputs, which required only 1.1 millivolts input for a 1-volt output, no perceptible waveform distortion occurred until 100 millivolts was applied. The Low input, with its fantastic 0.06-millivolt sensitivity, could withstand a 23-millivolt signal without distortion.

We found no flaws whatever in the performance of the TA-2000. All controls were smooth, precise, and quiet in their operation. Coupled with a power amplifier of equivalent quality, it should meet the needs of the most critical user, now and in the foreseeable future. At any rate, we cannot think of any feature that we would like to see added or any performance parameter that could be significantly improved at the present state of the art. The *Sony* TA-2000 sells for $329.50. The walnut cabinet is $24.50 additional. ▲

Design of a Light Meter

(*Continued from page 54*)

should drop to zero. This verifies performance of the 10-100 footcandle range.

Check the 1-10, 0.1-1, and 0.01-0.1 footcandle ranges in the same manner. It will be necessary to check each range in progressively lower ambient light levels. If all ranges check out properly, it may be assumed that everything is functioning. The light meter is now ready for calibration.

Calibration of the light meter requires a controllable light source, such as a photographic enlarger, and a reference light meter. The reference light meter should be an incident-reading type. When calibrating the meter with an enlarger, use the extension cable to facilitate placement of the photocell probe. Be sure that all comparative light readings are made with the reference light meter photocell and the photocell of the light meter being calibrated *exactly the same distance* from the source.

Set up a light level of 100 footcandles by adjusting the light source and using the reference light meter for indication. Put the photocell probe in the same place the reference light meter photocell was for setting up the 100-footcandle light level. Switch the light meter to the 10-100 footcandle scale and adjust $R1$ until the meter reads exactly 100 footcandles (full-scale).

Using the reference light meter, set up a new light level of 10 footcandles. Switch the light meter to the 1-10 footcandle range and adjust $R2$ until the meter reads exactly 10 footcandles (full-scale). Now switch back to the 10-100 footcandle scale and check to see that 10 footcandles is properly indicated. The meter should read approximately 1 on this range. A slight deviation will be noted in checking the end points of the light scales in this manner. The reason for the deviation is the slight nonlinearity of the photocell log characteristic.

Calibration of the two lowest ranges involves a slightly different technique. Since the lower limit of most conventional light meters is about 10 footcandles, it is not practical to set up light levels of 1 and 0.1 footcandle using a reference light meter as was done at 10 and 100 footcandles. Instead, a photographic enlarger set at a high known light level is used and the enlarger aperture stopped down to attenuate the light by known amounts. Remember that changing to the next higher f-stop reduces the light by one-half.

Set the enlarger for $f8$ and, using the 1-10 footcandle scale (previously calibrated), set a light level of 8 footcandles (vary the distance between the enlarger lens and the photocell). Now stop the enlarger down to *f*22. The light level will now be 1 footcandle. Check to see that the 1-10 footcandle range indicates approximately 1 footcandle. Switch to the 0.1-1 footcandle range and adjust *R*3 for a 1 footcandle (full-scale) reading.

To calibrate the lowest scale, the enlarger is again set at *f*8. This time use the 0.1-1 footcandle scale and set up a light level of 0.8 footcandle. Stop the enlarger down to *f*22. The light level will now be 0.1 footcandle. Switch to the 0.01-0.1 footcandle range and adjust *R*4 for a 0.1 footcandle (full-scale) reading. This completes the calibration of the light meter.

Using the Light Meter

The light meter is an incident-reading type; it measures the light incident upon a surface. This is distinguished from a reflected-type light meter which measures light being reradiated from a surface. Because of this difference, exposure readings made with this light meter must be made in a different manner from readings made with more conventional reflected-type light meters.

Incident light readings offer an advantage over reflected readings, particularly in difficult lighting situations such as a subject in the shade backlighted by the sun. Incident light falling upon the subject may be read and used to calculate a proper exposure. In the same circumstance, an averaging reflected-type light meter would be influenced by the strong backlight and indicate an exposure setting which would properly expose the background but underexpose the desired subject.

Light readings made with an incident light meter are taken with the meter located at the subject aimed back at the camera. The spherical diffuser accepts light from all directions, and effectively simulates the three-dimensional light reflecting characteristic of a subject. That is, it accepts light from all angles and weights it, depending upon the angle of incidence.

If the measurement is made in a location where both the camera and the subject are illuminated by the same incident light, such as outdoors in sunlight, the light reading may be made by merely pointing the light meter at the camera from a point anywhere between the subject and the camera.

In certain instances where it is impossible to make incident light measurements, a reflected type reading may be made using the light attenuator over the photocell instead of the diffuser. Such a reading will be as accurate as that obtainable with any reflected-light meter. ▲

NEW COLOR-ORGAN KIT

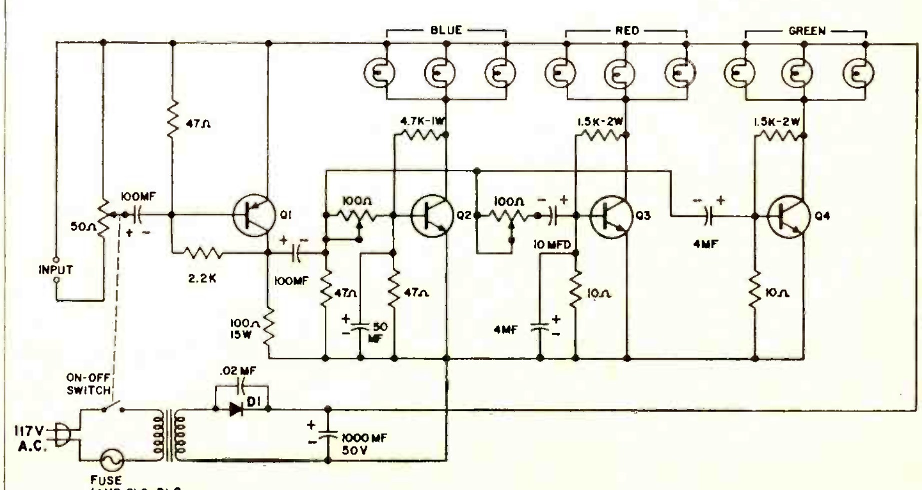
Three transistorized color channels provide up to 50 watts of lamp load in new Eico Model 3440.

LONG before the current interest in psychedelic light displays, we published a number of articles and circuits of various types of color organs. These devices produce a multicolored light display that varies in brightness and hue in accordance with the sound output of an audio system. Readers have always been interested in these circuits, and we have often wondered why some manufacturer did not come out with a solid-state, all-electronic color-organ kit. Well, *Eico* has done just that, and we recently had an opportunity of examining this company's new Model 3440 color organ.

The unit is simply connected across the loudspeaker of your hi-fi system; you can use two of them for stereo. The organ has no effect on the speakers or the system as it needs a mere 100 mW or so to produce a multicolored and varying light display. Three groups of colored lamps produce the light patterns. There are nine lamps in all; three are blue for the low frequencies; three are red for the mid frequencies; and three are green for the highs. All the lamps are mounted in front of a bent aluminum reflector, and their light is seen on a translucent plastic front panel measuring 10 in by 15 in. The cross-ridged pattern in the plastic diffuses the light nicely and gives it an interesting star-like appearance. A cluster of three automotive-type lamps are soldered into the circuit, and these are mounted at the center of the reflector. The lamps, which operate at 12 volts and 1 amp, are the same type (#93's) that are used in so many of the common high-intensity desk lamps, except that they are permanently colored red, green, and blue by the manufacturer. At the sides and corners of the reflector there are six additional, smaller colored lamps. These are #1488's, rated at 12 volts and 150 mA each. The total lamp load at full brilliance is thus close to 50 watts. Although this may not sound like much power, the lamps produce plenty of colored light even in a fairly well-lighted room.

The input signal is applied across a 50-ohm sensitivity control (see diagram) and then to the base of Q1, the input amplifier. Output from this stage is applied to three parallel channels, consisting of transistor amplifiers with lamp loads in their collector circuits. Very broad-band frequency-selective circuits are used in the bases of the three transistors to channel the low frequencies through Q2 and its lamps, the mid frequencies through Q3 and its lamps, and the high frequencies through Q4 and its lamps. Pots in the inputs of two of these channels allow the user to alter the pattern as he desires.

Price of the color organ is $50 in kit form, or $80 factory-wired. ▲



Capacitance Probes

(*Continued from page* 43)

external calibration system for the operating range desired. To accomplish this, several calibration points must be provided between *P*1 and the turbine shroud, and *P*2 with relation to the wheel blade tips.

The probes must first be loosened in their mounts so that there is sufficient freedom of movement for calibration purposes. Calibration blocks (similar to automobile feeler gages) are used to set the precise distances needed for calibration.

Probe *P*1 would be calibrated in the following manner, assuming a d.c.-coupled oscilloscope is used as the read-out device, as shown in Fig. 5. The scope is first balanced for d.c. usage (no deflection of the beam when the input gain is changed) and then the output of the capacitance meter is connected. A calibration block 200-mils thick is inserted between the engine shroud and the probe face. The probe mount is now tightened and the calibration block removed. The oscilloscope trace is placed on a conventional horizontal reference line using the beam-position control.

Again the probe mount is loosened and a 210-mil calibration block inserted between the probe and the shroud. The probe mount is again tightened and the block removed. Assuming we wish to calibrate the scope for 2 mils per division, we would set the input gain until the trace moves up by 5 divisions. This procedure is repeated several times until good repeatability is obtained.

After the calibration process is completed, the probe is placed at a convenient point from the shroud, at a distance not exceeding the linear operating range of the particular probe used. For small operating ranges (10-100 mils), feeler gages can be used for this purpose. Once this distance has been determined, the probe holder is tightened and the scope trace positioned on the reference line. The system is now ready for use.

Probe *P*2 is calibrated in much the same manner except an inside micrometer is used to set probe distances since the tip of the probe is not readily accessible.

Some possible test objectives for the example in Fig 5 would include: From probe *P*1 obtain the maximum vibration point in both displacement and G forces. Also from *P*1 obtain the maximum thermal growth of the shroud (expansion due to increased temperature). From probe *P*2 obtain the minimum clearance between the blade tips of the turbine wheel and the shroud.

The tests would be run in the following manner. Switch S1 would be placed on the vibration input to the capacitance meter, since no thermal stress information would be needed until the unit had reached maximum operating temperature.

The engine is started and slowly accelerated to operating speed. Normally there will be one or more shaft criticals (resonant points exhibiting high vibration) during the accelerating period. Once these points are located, the engine can usually be operated at each critical long enough to obtain data from the CRO or indicating meters on the capacitance-probe unit.

As an example, a maximum vibration reading may occur at 70 Hz. The displacement could be read directly from the CRO screen or the capacitance meter. It could also be converted directly into G forces in the manner outlined previously.

Also at the maximum vibration point the minimum blade tip-to-shroud clearance would probably occur. This could also be determined from the CRO or indicating meter located on the capacitance-probe unit.

In order to measure the maximum shroud growth due to a build up in temperature it would be necessary to operate the engine until conditions had stabilized. This point can be determined by a temperature-sensing device (thermocouple or similar probe) located near the point where thermal stress is being measured. By this means the operator is able to determine when the temperature has reached its maximum value. At this point, S1 is placed in the displacement position and the CRO input is switched to d.c. In this manner the d.c. voltage change will be indicated by a shift in the beam position directly proportional to any growth of the shroud due to the effects of temperature.

These few examples, while somewhat simplified, should serve to indicate the versatility of capacitance probes for both static and dynamic measurements, as used in industrial instrumentation. ▲

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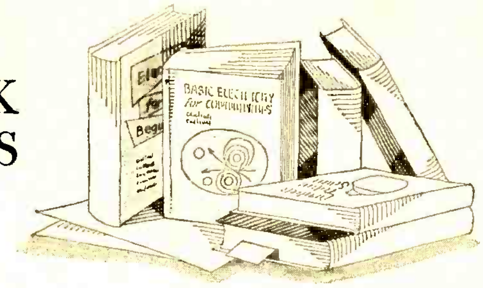
BOOK REVIEWS



"ADVANCED TECHNIQUES FOR TROUBLESHOOTING WITH THE OSCILLOSCOPE" by Robert L. Goodman. Published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 250 pages. Price $7.95. Paper bound edition $4.95.

Since more and more technicians are acquiring and using triggered-sweep scopes in their work, the author feels that to get the most from such sophisticated instruments, the user should be aware of its potentialities.

This book describes how triggered-sweep scopes work and how they can be used to cut down troubleshooting time. It also discusses how to interpret waveform displays and how to take advantage of a single- or dual-trace sweep in tube-type or solid-state circuit work. Although emphasis is on the trigger-sweep, most of the procedures described can be performed with a standard service scope—but more easily with a triggered-sweep.

The text is divided into eleven chapters, each of which is lavishly illustrated by photographs, schematics, graphs, waveforms, etc. The presentation is informal and the author's style "person-to-person."

Busy service technicians will find it worthwhile to take a little time out to digest this material, enabling him to do a faster and better job at the bench.

* * *

"HANDBOOK OF COAXIAL MICROWAVE MEASUREMENTS" by David A. Gray. Published by *General Radio Company*, West Concord, Mass. 01781. 158 pages. Price $2.00 paper bound.

This book is designed not for the microwave engineer but for students, technicians, and scientists and engineers from other fields who must make microwave measurements in their work. Because of the audience to which the book is addressed, the author has assumed that the reader is familiar only with basic a. c. theory and elementary algebra of complex numbers.

The text is divided into five chapters covering an introduction to coaxial transmission lines, the Smith chart, two-ports and discontinuities, some theoretical background, and basic measurement methods and procedures. A table of symbols completes the book. The text is clearly written and lavishly illustrated. The non-nonsense approach will be welcomed by those in search of information without having to wade through extraneous data and flowery embellishments.

* * *

"TRANSISTOR AND DIODE LABORATORY COURSE" by Harry E. Stockman. Published by *Hayden Book Company, Inc.*, 116 W. 14th Street, New York, N. Y. 10011. 114 pages. Price $3.95 soft bound.

This lab manual is designed to be used in technical-school courses, in high-school science classes, or by the student studying on his own.

Each experiment is prefaced by preparatory explanations, a general discussion of the topic, and followed by review questions. The experiments provide a basic groundwork in transistor technology.

Some of the areas covered include: plotting characteristic curves, measuring parameters of the three basic transistor connections, and investigating the audio amplifier, phase splitter, and output stages. Other experiments deal with more intricate transistor networks, such as the theory and operation of multivibrators and the concept of parametric action.

While this book is self-contained, amplification of certain points covered in the text must be obtained by referring to the author's "Transistor and Diode Network Problems and Solutions" published in 1967.

* * *

"DESIGNING WITH LINEAR INTEGRATED CIRCUITS" edited by Jerry Eimbinder. Published by *John Wiley & Sons, Inc.*, New York. 297 pages. Price $10.95.

This volume is a compilation of papers presented at the 1968 *EEE* Semiconductor-Device Clinic devoted to linear integrated circuits. All of the authors are applications engineers and their approach is a practical one. Among the companies represented are *Amelco, Raytheon, Philco-Ford, G-E, Fairchild, ITT, Signetics, Transitron, Sylvania, Motorola, Radiation, National Semiconductor, Westinghouse,* and *RCA.*

In sixteen chapters, the contributors take up the application of linear IC's in a wide variety of equipment. Emphasis is on "now" applications with currently available IC's. There is a lot of practical design information packed into these relatively few pages, and engineers involved in designing new equipment will find much food for thought.

* * *

"POPULAR TUBE & TRANSISTOR SUBSTITUTION GUIDE" compiled and published by *Tab Books*, Blue Ridge Summit, Pa. 17214. 157 pages. Price $4.95 leatherette, $2.95 paper.

This volume is divided into eight sections covering popular receiving tubes, industrial and commercial tubes, U. S. substitutes for foreign tubes, tube circuit and base diagrams, popular transistors, U. S. substitutes for foreign transistors, general-purpose transistor substitutes, and transistor base diagrams. Emphasis is on "popular" types, with off-beat items omitted.

Each tube or transistor is listed in numerical order then basing information is provided. Next the "preferred" substitutes are listed (if there are any) and then "good" substitutes which can be used in emergencies. This material is presented in tabular form for quick and easy reference.

* * *

"CIRCUITS, SIGNALS, AND NETWORKS" by Cyrus W. Cox & William L. Reuter. Published by *The Macmillan Company*, New York. 580 pages. Price $12.95.

This volume had its beginnings as class notes used by two colleagues at the South Dakota School of Mines and Technology. From their teaching experience, the authors have devised a system of presentation which has proved successful with their beginning electrical engineering students. The material can be used by those just starting their study of calculus and physics.

The book is divided into 15 chapters covering the nature of circuit parameters, network laws and energy sources, single-source techniques in single element-kind networks, simple circuits of more than one element-kind, sinusoidal steady-state, network analysis, operational representations of signals, operational methods of network analysis, complex plane and system behavior, special properties of the frequency response, matrix analysis of networks, special topics, magnetically coupled circuits, Fourier methods, and balanced polyphase circuits.

* * *

"MOST-OFTEN-NEEDED 1969 TELEVISION SERVICING INFORMATION" compiled by M.N. Beitman. Published by *Supreme Publications*, 1760 Balsam Rd., Highland Park, Illinois. 192 pages. Price $4.00 paper bound.

This is Volume TV-28 in this publisher's series of service data and covers sets from *Admiral, Airline, Emerson, General Electric, Magnavox, Montgomery Ward, Motorola, RCA, Sears Roebuck, Sharp, Sony, Sylvania, Westinghouse,* and *Zenith*. The format is the familiar one used in all of the "most-often" publications. ▲

Electrohydraulic Effect

(*Continued from page* 45)

can be checked by paradynamic switches, a principle of which was evolved by the author and shown in Fig. 5.

Paradynamic switches differ from classical switches in that a specimen under test is short-circuited rather than turned off. The effect is the same. Large currents are not allowed to pass through the specimen, since the switch provides an ultra-low shunt resistance. Contemporary crowbar circuits, used in some power supplies, are similar to this. During the short-circuit mode, a buffer protects the battery-type power supply from overloads. Paradynamic switches, equipped with high-current SCR's and timers, can stop test currents at any point of the dynamic "on" cycle, thereby permitting investigations of the glow and burn characteristics of squib wires intended for small-scale electrohydraulics and/or missile ignition systems.

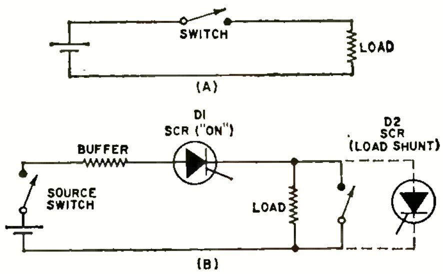


Fig. 5. Paradynamic switch is connected in shunt with power source and load. The buffer is used to protect power supply from overloads caused by short circuit.

Our discussion, which cannot be all-inclusive, might help to point out the features of various types of electrohydraulic systems and peripheral devices. The technology is a fluent one, offering much promise for now and for the immediate future. ▲

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Maroudas, N.G. et al: "The Mechanism of Electrohydraulic Comminution", Institute of Chemical Engineers, 2nd European Conference on Comminution, Amsterdam, 1966.

"It's your wife, again, with her nasty ultrasonic voice."

NEW PRODUCTS & LITERATURE

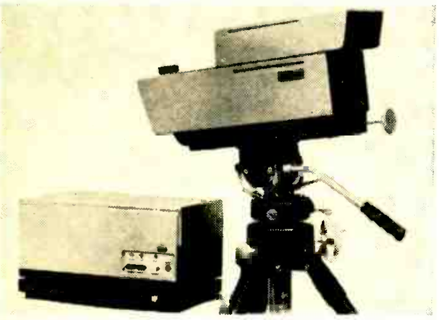
Additional information on the items covered in this section is available from the manufacturers. Each item is identified by a code number. To obtain further details, fill in coupon on the Reader Service Card.

COMPONENTS • TOOLS • TEST EQUIPMENT • HI-FI • AUDIO • CB • HAM • COMMUNICATIONS

COMPACT COLOR-TV CAMERA

A miniature color-TV camera which is designed primarily for industrial and educational applications is now on the market as the Model EDC 1000.

With a weight of only 29 pounds, the new all-



solid-state camera is exceptionally compact, portable, and easy to service. Its three controls make the camera easy to operate.

Using a single light-color level control, the new camera has a built-in encoder to obtain a direct NTSC signal. It also lends itself to the use of multiple cameras and special effects. It is equipped with a four-inch viewfinder, an f-2 lens capable of zooming from 16.5 mm for wide-angle shots to 94 mm for long-distance or telephoto shots, and two vidicons that produce good color resolution even at light levels as low as 160 footcandles. It has both a built-in cue light and a built-in intercom system.

The system consists of two units; the camera and a control and color sync unit. The latter, which automatically controls the camera and also weighs only 29 pounds, can be placed as far as 165 feet away from the camera. The camera measures 6½" x 11" x 22" and the control-sync unit measures 7" x 10½" x 17". Sony Corporation

Circle No. 1 on Reader Service Card

D.C. POWER SUPPLY

A miniature d.c. power supply with 50-watt output and three IC plug-in cards for dependability and easier and quicker maintenance is being offered as the PVC.

Designed as a stable source of regulated d.c. power in the low current line, it offers full protection with electronic current and voltage regulation. Scale multiplier switches on the front panel give up to 5:1 magnification of the voltage and current meter resolution on low voltage and current outputs. The unit is rated from 0 to 10, 20, and 50 volts, and 4, 2, and 1 A output, respectively. It can be used for IC development through relay driving. From no load to full load at constant input voltage, voltage regulation is within ±0.01% + 1 millivolt, while current regulation for load changes is less than ±0.2%, plus 5 mA from 10% of load to full load. NJE

Circle No. 126 on Reader Service Card

CUSTOM CABINET LINE

A new line of custom cabinets designed to suit kit builders, experimenters, and hobbyists has just been introduced under the name "Flexi-Cab."

Each unit consists of six panels and twelve "vise-grip" slides which can be assembled in minutes by merely joining the panels with the slides. The panels are made from 26-gauge vinyl-clad steel and are available in a choice of walnut wood grain or black leather with the front panel of brushed brass or chrome. Each unit is packaged with a set of pressure-sensitive labels that can be used to identify controls and functions.

Currently the cabinets are available in the following sizes: 3" x 4" x 4", 3" x 4" x 6", and 3" x 6" x 9". Bell Educational Labs

Circle No. 2 on Reader Service Card

GATE-CONTROLLED TRIACS

Twelve new gate-controlled, full-wave silicon triacs with a wider variety of voltage and current ratings and package styles are now available.

The new devices for the control of a.c. loads have applications such as heating controls, motor controls, solid-state relays, lamp controls, and power switching systems.

The two new 8-ampere types, 40668 and 40669, feature a plastic package with three horizontal leads for circuit board mounting. The two 6-ampere light dimmer types, 40664 and 40667, are designed for 240-volt line operation and are for the export market. There are four units in the 10-ampere category and four with a 15-ampere rating.

Information on the new devices will be forwarded on request. RCA Electronic Components

Circle No. 127 on Reader Service Card

DIGITAL TIME-INTERVAL PLUG-IN

A new time interval meter plug-in has just been introduced as the DP-210. When used with any main frame of the company's DSM 3200 digital measuring system, it provides digital display of either time interval or period measurements from 10 microseconds to 999 seconds with accuracy of ±0.0005% of reading ±1 digit. All circuitry is built into a compact plug-in which fits into the DMS main frame.

Completely separate "start" and "stop" inputs are provided, each with independent adjustments

of trigger level, attenuation, and slope choice. Thus start and stop commands from the device being measured may be from completely different sources and their isolation is maintained when connected to the DP-210 plug-in. A front-panel selector switch permits the choice of either time interval measurement of "one-shot" or repetitive phenomena or period measurement of repetitive signals. Either is displayed with resolution up to as great as 8 digits. This is achieved by readout of 3-digit sectors to obtain an accumulative 8-digit reading. Hickok

Circle No. 3 on Reader Service Card

ZENER CHIP DIODE KIT

A zener chip diode kit, designed for the hybrid microcircuit engineer to use for development projects or small production runs, is now available.

Providing a variety of 50 chips each of the 30 most popular zener voltages, the kit offers easy access as well as physical and environmental protection. The kit is housed in a walnut box with 30 plastic trays. All diodes are individually compartmented within the trays and the product data sheets furnished with the kit provide specific data on chips in the kit. Centralab Semiconductor

Circle No. 128 on Reader Service Card

HIGH-INTENSITY STROBE

A new high-intensity stroboscope which features a remote flashlamp for added flexibility has just been marketed as the E-40.

With the accessory remote speed controller and remote speed indicator, the strobe is suited for

the most demanding stop-motion applications, according to the company.

The basic model is an uncalibrated unit intended for the observation of rotating or cyclic motions where indication of speed is not important to the user. When speed indication is desired, the basic unit can be fitted with the direct-reading speed indicator. The remote speed controller can be added and placed with the speed readout for convenience of location. The basic strobe unit covers a speed range of 200 to 5000 flashes per minute. Wabash Instrument

Circle No. 4 on Reader Service Card

MATV CABLE POWER TESTER

A "green light" cable power tester for troubleshooting MATV systems is now being marketed as the SL-6900. The unit plugs in anywhere in an MATV system to test for the presence of 17-volt d.c. When power is present, the unit glows green. It is a simple "go/no-go" indicator with which to check cable-powered MATV systems.

The SL-6900 connects to any F-59 type fitting. It does not affect TV signals or the operation of the system in any way. JFD Electronics

Circle No. 5 on Reader Service Card

SECONDARY FREQUENCY STANDARD

The Model 300R secondary frequency standard can switch-select up to three standard frequencies in the 1000 to 6000 Hz range (200 to 10,000 Hz on special order).

Of all-solid-state design, the circuit employs quartz resonators for stability. It has a built-in attenuator for receive applications, an oven which maintains temperature within ± 1%, and an oven cycling indicator on the front panel.

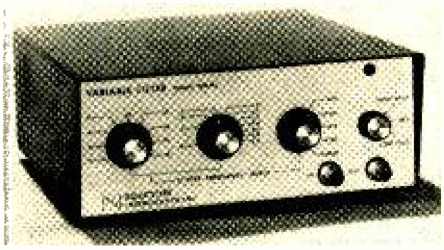
The instrument can be used for calibrating oscillators, scopes, and bridges, and can make accurate inductance and capacitance measurements. It also functions as a tone receiver or transmitter. Pioneer Electronics

Circle No. 6 on Reader Service Card

ELECTRONIC FILTERS

A complete line of electronic filters in the frequency range from 0.001 Hz to 2 MHz is covered in high-pass, low-pass, band-pass, and band-reject modes. The new instruments feature a switch-selectable response of Butterworth, Bessel, Chebyshev, or Gaussian with roll-offs from 24 to 96 dB per octave.

One unit features the Thompson transitional response, permitting continuous control of pole positions from Butterworth through Bessel. Timing accuracy ranges from 2% to 10% and is digital, semi-digital, continuous, or fully auto-



mated switching, which permits computer control.

A unique active module is used in all instruments in order to achieve wide dynamic range, low noise, temperature stability, and a response to better than 30 MHz in the high-pass mode. Reaction Instruments

Circle No. 129 on Reader Service Card

DIGITAL PANEL METER

A new digital panel meter, the DPM 1290, requires only seven square inches of panel area and offers three digits plus 100% overrange display, 0.1% ±1 digit accuracy.

Other features included in the standard model are: full buffered storage display, 1-2-4-8 BCD positive output logic, as well as true circularly polarized viewing windows. There are plug-in sockets provided for readout tubes. Replacement, when necessary, involves no soldering.

The entire 1½-pound unit is mounted from the front of the panel through the use of self-adjusting hardware. With the bezel snapped in place, no mounting hardware is visible. Weston

Circle No. 7 on Reader Service Card

HELICAL-SCAN VTR's

A new series of lightweight, portable helical-scan video tape recorders for CCTV applications has been announced. The new line includes a color unit.

The IVC-600 monochrome and IVC-600-C color recorders are both offered in cased or uncased versions for rack or console mounting. Tapes are interchangeable between units.

The IVC-600-C is said to achieve high-quality recorded pictures through a 4.2-MHz bandwidth. The monochrome recorder is capable of recording a color picture for replay on any color VTR using the company's format. One plug-in board is all that is necessary to play back full NTSC-type color images that were recorded on the black-and-white machine. The series uses 1-inch tape and offers one hour playing time. International Video

Circle No. 8 on Reader Service Card

DIGITAL PANEL METER

A new version of the Model 2800 series digital panel meter, offering improved overranging capability plus front-panel calibration adjustment, has been put on the market.

The instrument is just 2.8 inches high. This compact size is made possible by the use of IC's and other solid-state components. The meter is being offered in d.c. microamp, milliamp, milli-

volt, and volt range models. Accuracy is ±0.1% full-scale ±1 digit. There are three full-time digits plus an overrange "1." Readings are non-blinking, changing only when the measured value changes. The built-in storage circuit also provides BCD output for punch card or printer readout. Simpson Electric

Circle No. 9 on Reader Service Card

VTR SURVEILLANCE SYSTEM

A time-lapse video tape recording system designed especially for federally insured banks and other financial institutions to comply with the Federal Bank Protection Act of 1968 is now available as the TLV-2 Time Lapse Videocorder.

The unit features 48 hours of recording time on a standard 7-inch reel of video tape. All tapes recorded on it may be played back on all of the other 1-inch-format Videocorders in the company's line. The new unit may be used as a normal VTR for training, education, or in the time-lapse mode for surveillance recording, time and motion studies, studies of long-term nature growth phenomena, and preparations of annotated-graphics.

The TLV-2 may be used with any existing 2:1 interlace closed-circuit TV system. Sony Corporation

Circle No. 10 on Reader Service Card

HI-FI—AUDIO PRODUCTS

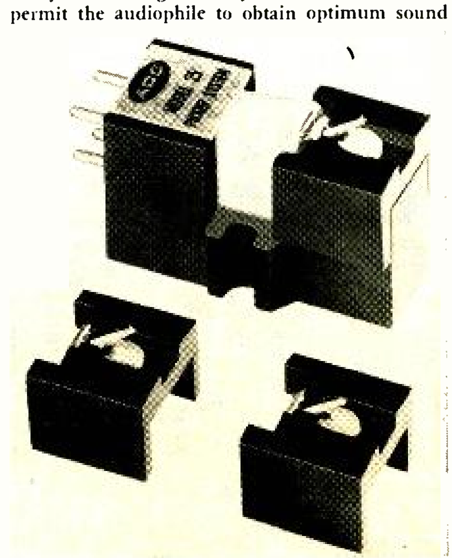
CASSETTES

Two new cassettes have just been introduced; the 251-C90 with 90 minutes of playing time and the 261-C120 which will record for 120 minutes. Both cassettes use the company's 200 series professional tape and both feature the Philips configuration and design for compact cassettes. The cassettes are supplied in a molded plastic case for permanent storage or mailing. Irish

Circle No. 11 on Reader Service Card

STEREO PICKUP SYSTEM

A new stereo pickup system has just been introduced as the Model 25. It provides three easily interchangeable stylus assemblies which permit the audiophile to obtain optimum sound



reproduction for the various record brands, each with its individual groove characteristics.

The induced magnet pickup has a sensitivity of 4 mV at 5.5 cm/sec recorded velocity. Tracking force range is ½ to 1¼ grams, while the frequency response is 10 to 24,000 Hz ± 2 dB. Channel separation is 30 dB from 30 to 12,000 Hz and 20 dB from 12,000 to 24,000 Hz. Compliance is 35 x 10^{-6} cm/dyne.

Stylus tip radii are: 0.0003" contact, 0.0007" lateral for the #251 elliptical; 0.0003" contact, 0.0009" lateral for the #252 elliptical; and 0.0006" lateral for the #253 spherical. Tracking angle is 15 degrees and the recommended load impedance is 47,000 ohms.

The system consists of the basic cartridge body and the three interchangeable styli, housed in a handsome black case, with walnut-inlaid hinged cover, lined in red velour. ADC

Circle No. 12 on Reader Service Card

TWO-WAY SPEAKER SYSTEM

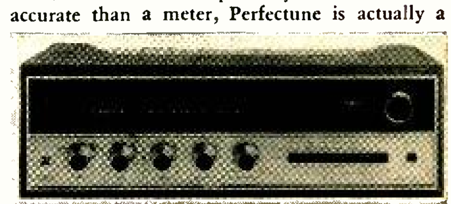
The CS-44 two-way speaker system is housed in a hand-crafted, oiled-walnut cabinet of decorator design. The cabinet is faced with a hand-crafted lattice grille.

The enclosure is an air-suspension type, housing an 8-inch high-compliance woofer with long-throw voice coil with special surround and a newly developed 2½-inch wide-angle dispersion cone-type tweeter. Response is 35-20,000 Hz with crossover at 2500 Hz. The CS-44 will accept input of up to 25 watts with a sensitivity of 96 dB per watt. Pioneer

Circle No. 13 on Reader Service Card

100-WATT FM-STEREO RECEIVER

The Model 342C 100-watt FM-stereo receiver incorporates the new "Perfectune" automatic tuning circuitry—a light that automatically goes on when a station is perfectly tuned in. More accurate than a meter, Perfectune is actually a



miniature computer. It instantly senses the FM signal and indicates when the signal is tuned for best reception and lowest distortion.

Realignment of the receiver's i.f. section has been eliminated by using a quartz-crystal lattice filter. This is factory aligned and need not be aligned again.

Much of the circuitry in the multiplex section is encapsulated in an IC which incorporates 40 transistors and 27 resistors. The company claims that the IC multiplex gives better stereo separation (40 dB) than the conventional PC configuration. The circuit is modularized for easy servicing.

Frequency response is 20-20,000 Hz, −1 dB; power is 100 w at 4 ohms, 80 w at 8 ohms IHF.

The receiver measures 15¾" wide x 5" high x 11½" deep. H. H. Scott

Circle No. 14 on Reader Service Card

RADIO/CASSETTE RECORDER

A compact AM-FM radio/cassette recorder has just been introduced as the RK-95. The combination features fast loading and recording from its own AM-FM radio or live from a microphone. In addition, the RK-95 offers push-button keyboard-type controls for stop, rewind, fast forward, play, and record, plus record safety interlock button to prevent accidental tape erasure.

The unit has a built-in 2¾" dynamic speaker, recording level and battery voltage meter, auxiliary input, external speaker or earphone output, and a capstan drive for 1⅞ in/s. The unit can record up to 120 minutes on one cassette cartridge. It will operate on four "C" cells or 117-volt a.c. with an optional a.c. adapter.

Housed in a black finished case with chrome and walnut trim, the unit comes with a remote-

control mike and stand, blank 60-minute cassette, earphone, vinyl accessory pouch, shoulder strap, and batteries. It measures 7" wide x 9½" deep x 2⅛" high and weighs 4½ lbs. Lafayette

Circle No. 15 on Reader Service Card

BULK ERASER

The Model #9 magnetic tape bulk eraser is designed to accommodate fully loaded magnetic tape reels with dimensions up to 1⅜" x 16" used with the latest audio tape recording equip-

ment. The unit is capable of erasing tapes used in recording studios, radio stations, data processing centers, and research laboratories.

It will erase saturated tapes at the rate of up to 100 reels per hour. All recorded data, audio pulses, or any kind of signal from d.c. to video is erased to better than 80 dB below saturation recording level. The eraser is housed in a sturdy mahogany case impregnated with a clear coating to withstand hard wear. Ferranti

Circle No. 16 on Reader Service Card

PORTABLE TAPE RECORDER

The Sony "Servocontrol 800-B" portable tape recorder features a built-in capacitor electret microphone and an integrated-circuit amplifier. The permanently charged electret diaphragm is said to provide exceptionally high sensitivity and wide directivity.

The recorder will operate at all four tape speeds. Frequency response is 30-18,000 Hz at 7½ in/s, with wow and flutter 0.1% at that speed. Signal-to-noise ratio is 48 dB.

The 800-B may be operated from either a.c. or battery. It has a 5-inch reel capacity and dual-track recording, a vu meter, and digital tape counter. It comes with a F-265 cardioid microphone for hand-held and remote stop/start use in addition to the built-in electret. A three-position switch permits the user to select internal, external, or mixed microphone operation. Superscope

Circle No. 17 on Reader Service Card

CB-HAM-COMMUNICATIONS

12-CHANNEL WALKIE-TALKIE

The "Dyna-Com 12" is a 5-watt, 12-channel, crystal-controlled CB portable which, with optional accessories, can be operated on 12-volt d.c. and 117-volt a.c. for mobile and base-station applications as well.

The unit features 5 watts of input power; uses 14 transistors, 6 diodes, and 1 posistor; and has an automatic compressor range-boost circuit. There is a pi-network antenna output and a battery condition/automatic relative r.f. indicator, mechanical filtering for sharp selectivity, variable squelch plus automatic noise limiting, TVI trap, push-pull audio modulation, superhet receiver, and an r.f. stage with 0.7 μV sensitivity. The combination battery pack and external battery charger jack permits the set to be in continuous service.

The unit measures 3¼" wide x 10½" high x 2$\frac{1}{16}$" deep. It comes complete with transmit and receive crystals for channel 10, telescoping whip antenna, and leather shoulder strap. Lafayette

Circle No. 18 on Reader Service Card

PHONE PATCH

A phone patch which is designed to be used with two-way radio systems is now available. It permits patching into a telephone line from a mobile station or the mobile unit can be patched in from a telephone line. It can also be used with paging systems, portable systems, and receiver-only systems.

The unit uses solid-state circuitry and incorporates an IC audio amplifier. It is a direct-wire

connection to the telephone system to eliminate problems with hum pickup from fluorescent lamps, adding machines, etc.

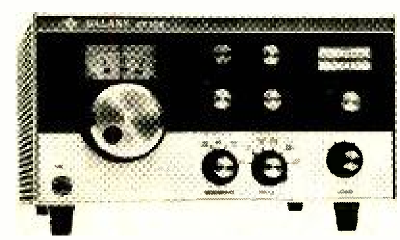
Prior to installation, the local telephone company must be contacted for the installation of the telephone switch and protective network which provides the telephone connections for the phone patch. Motorola Communications

Circle No. 19 on Reader Service Card

HAM TRANSCEIVER

The new GT-550 is a 5-band SSB transceiver designed for either mobile or fixed-station ham applications. Although it measures only 11¼" x 12⅜" x 6" and weighs 17 pounds, it has 550 watts SSB power, 360 watts c.w.

A matching line of accessories designed to be used with the new transceiver is available, including an amplifier, r.f. console, remote v.f.o., and a speaker console. Also available as accessories are an a.c. power supply, mobile power supply, phone patch, c.w. filter, VOX ac-



cessory, calibrator, mobile mounting bracket, and a floor-board adapter.

An illustrated brochure giving full details on the line is available on request. Galaxy

Circle No. 20 on Reader Service Card

MANUFACTURERS' LITERATURE

RELAY CATALOGUE

A list of 481 different relays are featured in a new stock catalogue, No. 270. This revised 16-page publication incorporates several new products including a new line of mechanically actuated and electrically actuated air dashpot time-delay switches for industrial application. Also covered is a new low-cost, solid-state time-delay relay capable of adjustments of up to 300 seconds.

Besides the new products, the catalogue features a full line of general-purpose, telephone-type, dry-reed, mercury-wetted, industrial power, plug-in, coaxial, and hermetically sealed relays as well as PC, latching, and high-voltage types. Magnecraft

Circle No. 130 on Reader Service Card

PHOTO CONTROLS

A new catalogue which provides full details on "dusk-to-dawn" lighting by means of photocontrols is now available. The publication also features a section on fixtures and where to buy them. LGM Electronics

Circle No. 21 on Reader Service Card

PRECISION SLIDE SWITCHES

A four-page booklet describing new "Phase II" double-wipe slide switches is now available as Bulletin No. 178.

The publication contains complete details on features built into the new switch, including a newly designed slider for either 3- or 6-A a.c. ratings, improved operator feel, and increased life and reliability.

Engineering drawings throughout describe the mounting configurations and contact arrangements available with the new series. Switchcraft

Circle No. 131 on Reader Service Card

ANTENNAS & ANTENNA SYSTEMS

A 64-page catalogue of antennas and antenna systems, covering the frequency range of 2 MHz to 1100 MHz, is now available for distribution.

Most of the items listed are available for off-the-shelf delivery, in kit form, as systems, or installed. The listing includes rotatable log periodics, fixed log periodics, transportable log periodics, yagis, broadband monopole and discone arrays, h.f/SSB circuit antennas for both fixed and mobile applications, v.h.f. and u.h.f. fixed and mobile antennas, manpack and portable antennas, dipoles and doublet systems, rotators and accessories, and antenna rotating joints. Hy-Gain

Circle No. 22 on Reader Service Card

STANDARD RELAYS

The new SC-4 catalogue lists over 450 electronic relays and contactors in the RBM Controls line. The publication includes a full line of off-the-shelf models complete with pictures, prices, full technical data, and specifications.

The 20-page catalogue covers a.c. and d.c. general-purpose relays, power contactors, industrial contactors, glass-reed relays, and time-delay relays. Essex International

Circle No. 132 on Reader Service Card

SEMICONDUCTOR CATALOGUE

A new 32-page catalogue which covers both standard and industrial semiconductors and includes complete specifications on the firm's latest types, is now available for distribution.

The publication includes a wide range of semiconductors from silicon and germanium devices to Hall-effect devices and digital IC's. In addition to providing full electrical data on each item, mechanical specifications and dimensional drawings are included. Siemens

Circle No. 133 on Reader Service Card

D.C. VOLTAGE STANDARD

A four-page data sheet (15-76) has been issued describing what the company claims is the world's first 0.001% d.c. voltage standard. The two-color sheet gives specifications, special features, and a typical system for the high-accuracy instrument. Cohu

Circle No. 134 on Reader Service Card

TUNABLE TONE TRANSFORMERS

A new four-page brochure describing tunable, multi-frequency tone transformers has just been issued as Bulletin 5113.

These electronic components plug into printed-circuit boards and are designed for use in communications equipment using tones to accomplish signaling functions. Besides the capabilities of the transformers, the bulletin describes physical characteristics and includes dimensional drawings. Typical circuit applications and transformer schematics are included. Sangamo

Circle No. 135 on Reader Service Card

MEDIUM-POWER DTL IC's

A revised edition of the technical bulletin on the CD2300 series of medium-power DTL integrated circuits has been released as File No. 374.

The revised information in this bulletin includes tighter limits on many parameters and new information on dual flip-flops. The units covered include the CD2300 ceramic flat-pack, CD2300D ceramic dual-inline package, and the CD2300E dual-inline plastic package types. RCA Electronic Components

Circle No. 136 on Reader Service Card

AIR TRIMMER CAPACITORS

How a concentric ring air trimmer capacitor is constructed, how it works, and what are its main design features are detailed in a new 8-page brochure entitled "The Inside Story."

Illustrated by exploded views and cutaway drawings, the brochure compares the firm's line of non-rotating air trimmers with conventional air trimmers on a part-by-part, feature-by-feature basis. Details on construction and parts are clearly shown. Voltronics

Circle No. 137 on Reader Service Card

SOLDERING-IRON TIP DATA

A 28-page, two-color catalogue covering an extensive line of soldering-iron tips is now available for distribution.

Featuring accurate drawings of tips in diameters from ⅛" to 1⅛", the new file-folder style catalogue is designed to enable tip users to specify diameter, length, point shape, shank style, and point tinning requirements when ordering.

A complete selection of diamond, cone, chisel, screwdriver, bevel, turned down, and tapered tips is illustrated, as well as plug, sleeve, and threaded-shank styles. Plato Products

Circle No. 138 on Reader Service Card

LEAKAGE CURRENT

UNDERWRITERS' Laboratories, acting for U.S.A.S.I., has released its findings on maximum limits for household appliance leakage current to which users may be safely exposed in normal use. The recommendation is that such leakage current not exceed 0.5 mA, and applies to appliances having 2-wire portable cord connection, rated for use on 120-volt circuits.

To determine the maximum level, a UL research team devised a program of measurements and tests which included having a subject make a series of motions with a full cup of rice while touching sources of varying leakage current. If the leakage was sufficient to create an involuntary reaction by the subject, and caused rice to be spilled, this was a factor in determining that the current was considered excessive. ▲

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ELECTRONICS MARKET PLACE

COMMERCIAL RATE: For firms or individuals offering commercial products or services. 85¢ per word (including name and address). Minimum order $8.50. Payment must accompany copy except when ads are placed by accredited advertising agencies. Frequency discount: 5% for 6 months; 10% for 12 months paid in advance.

READER RATE: For individuals with a personal item to buy or sell. 50¢ per word (including name and address). No minimum! Payment must accompany copy.

GENERAL INFORMATION: First word in all ads set in bold caps at no extra charge. Additional words may be set in bold caps at 10¢ extra per word. All copy subject to publisher's approval. **Closing Date:** 1st of the 2nd preceding month (for example, March issue closes January 1st). **Send order and remittance to:** Hal Cymes, **ELECTRONICS WORLD,** One Park Avenue, New York, New York 10016.

FOR SALE

JUST starting in TV service? Write for free 32 page catalog of service order books, invoices, job tickets, phone message books, statements and file systems. Oelrich Publications, 4040 North Nashville Avenue, Chicago, Ill. 60634.

GOVERNMENT Surplus Receivers, Transmitters, Snooperscopes, Radios, Parts, Picture Catalog 25¢. Meshna, Nahant, Mass. 01908.

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CONVERT any television to sensitive big-screen oscilloscope. Only minor changes required. No electronic experience necessary. Illustrated plans, $2.00. Relco-A22, Box 10563, Houston, Texas 77018.

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- **1700 transistor types at 39¢ each.**
- **40 watt germanium power transistor, same as Delco 501, 2N278 (etc), cat. #349, 59¢ each.**
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- **Motorola 2500 ma. at 1000 piv, high voltage/current epoxy silicon rectifier, axial leads. Cat. #HEP-170, 49¢ each.**
- **2 Printed circuit I.F. transformers, 4 lug. 455 kc input and output, cat. #1909P4, 99¢ each.**
- **RCA UHF transistor type TV tuners, KRK-120 (long-shaft) cat. #UHF-20; KRK-120 (short-shaft), cat. #UHF-21, each $4.98.**
- **RCA VHF transistor type TV tuners, KRK-146, cat. #VHF-74, $9.99 each.**
- **Transistorized U.H.F. tuners used in 1965 to 1967 TV sets made by Admiral, RCA, Motorola, etc. Removable gearing may vary from one make to another. Need only 12 volts d.c. to function. No filament voltage needed. Easy replacement units. Cat. #UHF-567, $4.95.**
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- **Kit of 30 tested germanium diodes. Cat. #100, 99¢.**
- **Silicon rectifier, octal based replacement for 5U4, 5Y3, 5AS4, 5AW4, 5T4, 5V4, 5Z4. With diagram. Cat. #Rect-1, 99¢ each.**
- **7", 90° TV bench test picture tube with adapter. No ion trap needed. Cat. #7BP7, $7.99.**
- **Tube cartons 6AU6 etc. size, $2.15 per 100. 6SN7 etc. size, $2.55 per 100. 5U4GB size, $2.95 per 100. 5U4 G size, 3¢ each.**

Send for complete free catalog. Include 4% of dollar value of order for postage. $5 MINIMUM ORDER. Canadian check, 8% dollar differential.

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CIRCLE NO. 121 ON READER SERVICE CARD

WHOLESALE components: Manufacturers and distributors only. Request free catalog on business letterhead. **WESCOM,** Box 2536, El Cajon, California 92021.

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EUROPEAN wholesale new products catalog. $1.00 refundable. Deecow, 10639 Riverside, North Hollywood, Calif. 91602.

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LASER systems, holography. Request illustrated brochure. XenoX Company, 5848 Sixty-Seventh Street, Sacramento, California 95824.

TEKTRONIX TYPE 570 CURVE TRACER, good condition, $195.00. Mike Strand, 2343 Oakmont Ave., Santa Ana, Calif. 92706.

COMPUTER INTEGRATED CIRCUIT technical data. Characteristics, terms explained for low cost ICs. $2.00. Logic House, Box 1048, Delran, N. J. 08075.

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PROXIMITY TACHOMETER, for pick up from signal magnets. Plans $3.00. Reb Engineering, P.O. Box 276, Monroeville, Pa. 15146.

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OSCILLOSCOPE improvement kits. High speed triggersweep eliminates sync problems. Dual trace FET switch displays two waveforms together. Solid-State Services, P.O. Box 901, Cupertino, California 95014.

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10 Hz to 220 MHz: H.P. 524B/525A/525C	950.00
10 Hz to 510 MHz: H.P. 524D/525A/525C	1095.00
2 MHz Preset & Eput Solid-state inline	395.00
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A FEW SCOPES FROM OUR SCOPE LIST:

Tekt. #531 with plugin	415.00
Tekt. #535 with plugin	715.00
Tekt. #536 with 2 plugins, calibrated	770.00
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Tekt. #545 with plugin	790.00
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Fairchild 2-trace Solid-State 5" scope	895.00
Tekt. #581 with #81 adapter, calibrated	975.00
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Meas. Corp. #82: 20 Hz to 50 MHz CW or AM up to 50%. Output calib. to 1 v into 50 ohms. It is the only LF Gen. with Piston Attenuator: easy to use, no resistor burnouts. Like new. w/book & NBS-traceable calib. **450.00**

Marconi TF-801D/1: 10 to 470 MHz CW & AM up to 90%. Xtl-calib each 5 MHz and resettable dial hairline. AGC keeps level constant. 0.1 uv to 1 v from 50 ohms into Type N. Cap.-coupled turret switch, no rubbing contacts. Practically zero leakage & FM. Like brand new. w/NBS-traceable calib & book **595.00**

H.P. #608A: 10-500 MHz CW or AM up to 90%. 0.1 uv to over 1.0 v into 50 ohms. Like new, NBS-traceable calib. & book **395.00**

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ULTRA-WIDE-BAND RECEIVER:

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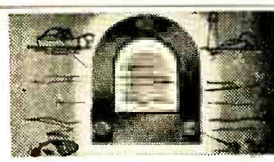

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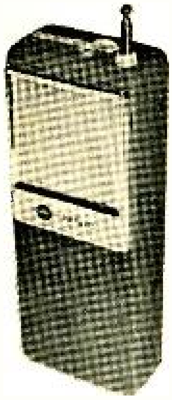

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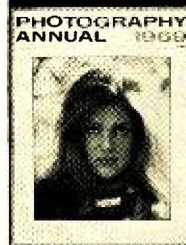

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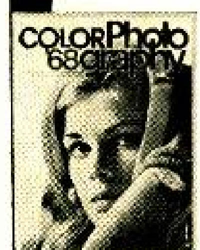

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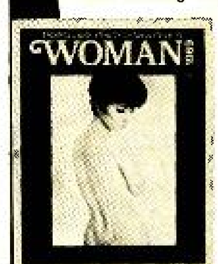

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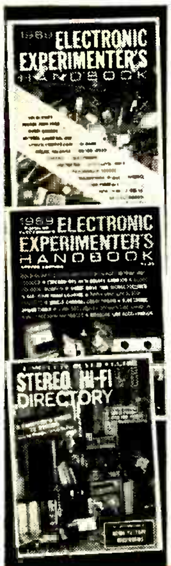

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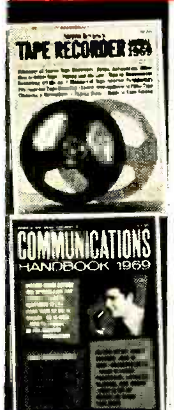

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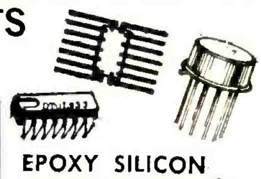

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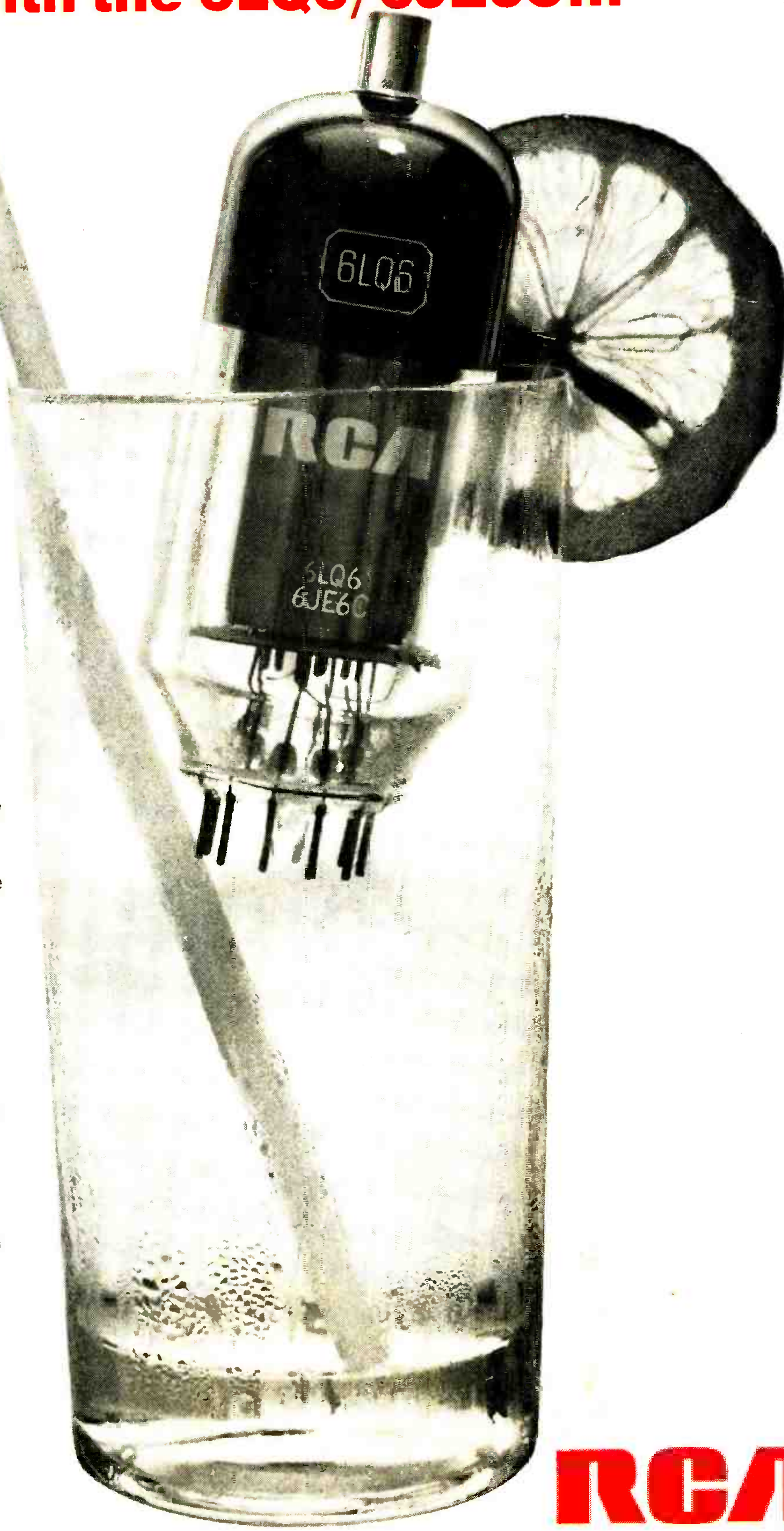

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